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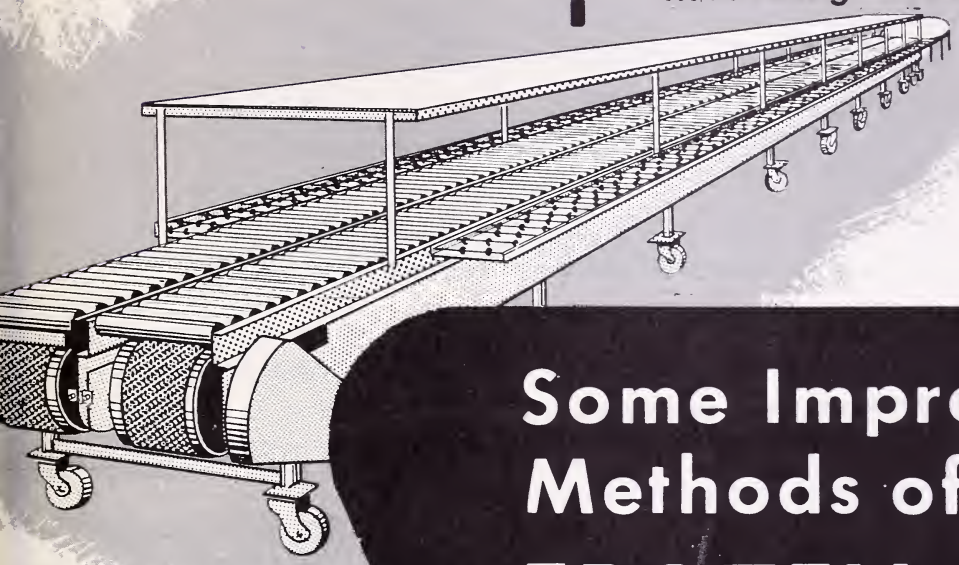
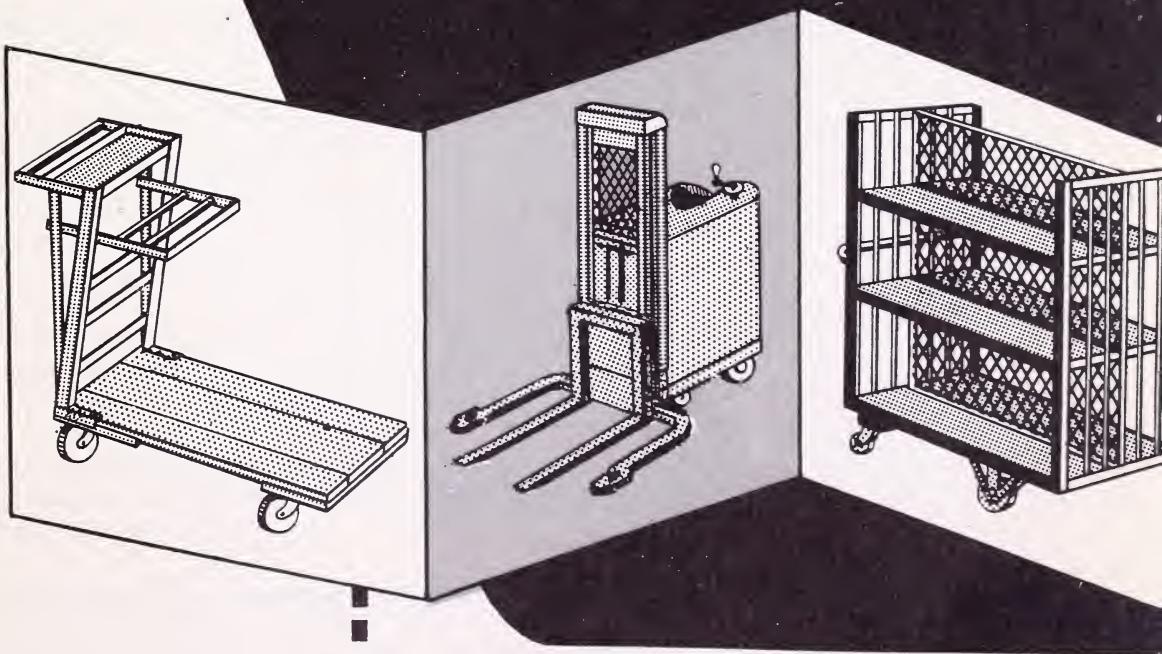


Some Improved Methods of Handling FROZEN FOOD in Wholesale Plants



UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service

Other reports on the handling of frozen foods and produce issued by the U. S. Department of Agriculture include:

The Market Information Needed on Frozen Foods, 1950.

How Fresh Fruit and Vegetable Distributors Can Get More Out of Their Materials-Handling Equipment, June 1950.

Use of Recording and Transcribing Equipment in Loading Delivery Trucks of Produce Wholesalers, May 1951, Agriculture Information Bulletin No. 43.

An Analysis of Some Methods of Loading Out Delivery Trucks of Produce Wholesalers, May 1952, Marketing Research Report No. 15.

Purchases of Frozen and Canned Foods by Urban Families as Related to Home Refrigeration Facilities, February 1954, Marketing Research Report No. 60.

Availability and Display of Frozen Foods in Retail Stores in Washington, D. C., August 1954, Marketing Research Report No. 73.

Frozen Food Movement Into Retail Outlets, March 1955, AMS-19.

Improved Handling of Frozen Foods in Retail Stores, September 1955, Marketing Research Report No. 104.

Cold Storage Report, issued monthly with an annual summary.

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PREFACE

This report is a followup of the reports entitled *Marketing Frozen Foods--Facilities and Methods,* June 1949, an unnumbered publication and *Planning a Wholesale Frozen Food Distribution Plant,* June 1952, Marketing Research Report No. 18, published by the U. S. Department of Agriculture. The second of these reports was an analysis of some of the effective operating practices of frozen food wholesalers found in existence at that time, as well as a handbook for distributors who contemplated making changes in their plants. Among other things, the study pointed out that the methods of receiving food stocks, order assembly, and loading out of delivery trucks in many of the plants appeared to be inadequate for efficient handling of frozen foods.

With these shortcomings in mind, additional research was undertaken to develop improved methods and equipment necessary to make frozen food distribution operations more efficient. The improved systems evaluated in this report are the results of research and development work in selected pilot plants, and represent a few of the improved methods currently used in assembling frozen food orders and in handling frozen foods in distribution plants.

The research which is the basis for this report was conducted under the general supervision of William H. Elliott, Head, Handling and Facilities Research Section, Transportation and Facilities Branch, Marketing Research Division, Agricultural Marketing Service, under authority of the Agricultural Marketing Act of 1946.

The research was conducted with the cooperation of the National Wholesale Frozen Food Distributors' Association, Harry K. Schauffler, executive director.

The wholesale frozen food distribution plants in which various phases of the work were done are as follows:

American Service Company, Atlanta, Ga.
Bershire Frosted Foods, Inc., Pittsfield, Mass.
Burris Food Distributors, Inc., Milford, Del.
Capitol Fish Company, Atlanta, Ga.
City Foods Company, Detroit, Mich.
Frankford Grocery Company, Inc., Philadelphia, Pa.
Gaudio Brothers, Inc., Camden, N. J.
Global Frozen Foods, Inc., New York, N. Y.
Roanoke Frosted Foods Company, Roanoke, Va.
Snow Kist Frozen Foods Corporation, Jersey City, N. J.

A substantial contribution to the design of equipment was made by the research and development engineers of the Rapids-Standards Company, Inc., Grand Rapids, Mich., and the N. M. Quint Company, Detroit, Mich.

Credit is due Joseph F. Herrick, Jr., agricultural economist, Transportation and Facilities Branch, and Frederick C. Winter, associate professor of industrial engineering, Columbia University, and consulting industrial engineer, Transportation and Facilities Branch, for guidance and for many helpful suggestions.

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SOME IMPROVED METHODS OF HANDLING FROZEN FOOD IN WHOLESALE PLANTS

By James A. Mixon, agricultural economist 1/ and
Theodore H. Allegri, industrial engineer
Transportation and Facilities Branch

SUMMARY

A primary concern of the wholesale frozen food distributor is to increase the productivity of his handling system. Through the cooperation of several typical distributors of wholesale frozen foods, three improved systems of handling frozen foods were developed and tested.

In a plant which handled a daily volume of about 2,000 cases, the change from a 4-wheel hand truck and roller conveyor system to a power conveyor and straddle-type fork truck operation resulted in a saving of $7,850 a year (15 percent). The saving of 10 cents per order will enable the distributor to pay for the new equipment, costing $12,725 in less than 2 years.

It was found that in a plant handling over 2,000 cases, the use of a single-deck cart system, developed in the course of this project, increased order assembly productivity and saved about 65 percent of the public storage costs. With the savings of almost 7½ cents an order, the distributor should be able to pay for the new equipment within 2 years. Total annual savings were estimated at $16,300, or 18 percent of the cost of the former method.

In the small-volume plant (daily volume 1,000 cases), the change from a manual handling system using hand trucks and wheel conveyor to a multiple-deck cart system, also developed in the course of this study, achieved estimated savings of nearly $6,570 annually, or 28 percent of the cost of the former method. This represented a saving of 13 cents per order, bringing the total materials-handling cost down to 34 cents per order.

Increased order assembly productivity resulting from this research has been tabulated as follows:

Plant description	Orders per man-hour		Productivity increase
	Old method	New method	
	Number	Number	Percent
Power roller conveyor system (Medium volume - 2,000 cases daily)	3.98	5.47	37.5
Single-deck cart system (Large volume - over 2,000 cases daily)	4.50	6.25	39.0
Multiple-deck cart system (Small volume - 1,000 cases daily)	3.26	5.00	53.4

1/ James A. Mixon, formerly a staff member of the U. S. Department of Agriculture conducted the earlier phases of this study and analysis before leaving the Department.

An analysis of this tabulation reveals that the large-volume distributor had the highest productivity rate per unit of labor, that the small-volume dealer had the lowest productivity, and the medium-volume dealer fell about midway between the other two. The cost per order varied for these distributors in reverse order to their volume, with the large-volume distributor having the lowest cost per order, and the low-volume distributor having the highest cost per order. However, from the improvements that resulted from this research in order assembly operations, it is evident that the low-volume distributor can lower his costs and thereby strengthen his competitive position by organizing his stock properly, by selecting equipment suitable for his operations, and by analyzing the weak points of his materials-handling system in much the same manner as was done in this study.

BACKGROUND MATERIAL

The principal handling jobs at wholesale frozen food warehouses, in the sequence of their occurrence, are: (1) Receiving merchandise into the distribution plant; (2) assembling orders; and (3) loading delivery trucks. In many plants these operations are closely integrated and are difficult to separate. In almost every instance, the method used for performing one operation in a job or cycle influences the method by which other operations are performed. It is necessary, therefore, to consider the overall operations when attempting to improve materials-handling methods in wholesale frozen food distribution plants.

Receiving is the physical acceptance of cases or cartons of frozen foods into a wholesaler's warehouse. It involves the performance, in succession, and usually in a regular sequence or order, of the following cycle of operations: (1) Unloading from railroad cars or motortrucks; (2) transporting to the warehouse; and (3) storing.

When individual frozen food orders are assembled in the plant for loading onto delivery trucks, *order assembly* covers the cycle of operations performed in: (1) Removing full cases or cartons of frozen foods from stacks in the storage area; (2) transporting the cases from the storage point to the order-assembly room; (3) stocking chutes, bins, racks, or other facilities in the order-assembly room used for temporarily holding supplies; (4) assembling items for filling, marking, and checking individual orders; (5) transporting assembled orders to the order-holding room; and (6) stacking the assembled orders in the holding room. The first three of the operations in this cycle usually are referred to by wholesalers as *stocking*. Modifications may be made in this cycle of operations in individual plants, depending on the plant layout and the types of equipment used. As an example, if assembled orders are stacked in the order-assembly room for holding prior to delivery, transportation may cover only the distance from the end of the order-assembly line to the stacking point rather than to an order-holding room. Moreover, stacking assembled orders may consist of positioning a loaded skid or pallet with the load intact, rather than removing the orders and manually stacking them.

Truckloading is the movement of the merchandise from the order-assembly room to the shipping apron where it is stowed in the truck in its proper location for delivery by the route man, or truckdriver.

Working stock is that part of the distributor's frozen food supply that is used in order assembling, usually 2 or 3 days' supply of frozen foods. *Reserve stock* is a supply

of frozen food from which the working stock is drawn. This may range from a supply for several days to several months or more.

The total amount of frozen food delivered to one customer by a wholesaler in a single delivery is an *order,* and a single product within an order is an *item.* An order may consist of a single item or a large number of items. Moreover, an order may consist of only six consumer-size packages of one item or it may consist of full cases of each of a number of items and less-than-case lots of other items. Orders delivered to retail stores, restaurants, or institutions usually consist of packages of some items in less-than-case lots and some items in full-case lots. Less-than-case quantities of a single item are usually sold in minimum quantities of a dozen or a half dozen.

Importance of Reducing Handling Cost

It is estimated that receiving, order assembly, and truckloading account for about 30 percent of the cost of operating a wholesale frozen food business, exclusive of the cost of merchandise sold. The remaining 70 percent of operational costs are accounted for by sales and allied expenses, delivery costs, office expenses and other paper work, administrative expenses, and overhead costs. Labor and equipment costs for handling frozen foods in a moderate-volume (2,000 cases per day) wholesale plant at the time of this study (1954) are estimated at $30,000 to $40,000 annually. In most plants improved handling methods should reduce these costs as much as 25 to 30 percent. A cost reduction of $8,000 to $12,000 annually is an appreciable gain in marketing efficiency for the moderate-volume distributor.

How Improved Handling Methods Were Developed

Because of the necessity for splitting cases in assembling individual frozen food orders, in-plant *order-assembly* operations usually require special facilities and equipment and account for a relatively large part of a plant's total handling costs. In this study, therefore, emphasis was placed on the development of improved work methods and equipment for assembling orders.

In 1952, when the research which is the basis for this report was initiated, over 50 percent of the frozen food wholesalers in the United States used *order-assembly lines* consisting, in part, of gravity-type roller or wheel conveyors for filling, marking, and checking individual orders. Because of their prevalence, gravity conveyor assembly lines and the methods employed with them were used as a base from which to develop and compare new methods and equipment.

In order-assembly lines, gravity conveyors, which are used in conjunction with tables, bins, or work benches, are set at a level rather than an inclined position and the surface of the conveyor is used both as a packing shelf and as a means of moving cases and cartons for individual orders between stations along the line. In zero order-assembly rooms conveyor (nonpowered) assembly lines are located in the same room with working stocks (fig. 1). In *warm* assembly rooms (rooms held at between 30° and 40° F.) the working stock is obtained from a room at or near 0° F., called a *zero* room, by means of chutes located in the wall dividing the two rooms (fig. 2). Storage capacity in zero rooms is used to accommodate as large a supply of working stock as possible. Because of the higher temperatures, the working stock in warm rooms must necessarily be of much smaller amount than in zero rooms. 2/

2/ A chart showing the average rise in temperature of the packaged frozen food when removed from a -5° F. storage room and held in unopened cases, opened cases, and loose packages for 6 hours in a room held at a constant temperature of 36° F. appears on page 21 of Marketing Research Report No. 18, *Planning a Wholesale Frozen Food Distribution Plant.*

The working stock in warm rooms, therefore, must be replenished frequently throughout a night's operation. Merchandise is usually handled more times in a warm room than in a zero room, thus adding to handling costs.

Gravity conveyor assembly lines usually are divided into stations at each of which a worker fills only part of an order. The order assembly crew fills orders, handles and marks invoices, marks cartons with customer's identification, and checks the orders for errors.

Work sampling (ratio delay) studies of order assembly and truckloading operations were made in 5 selected plants which used gravity conveyor assembly lines, to determine: (1) The relative importance in terms of labor and length of time required for each operation in the cycle of operations; (2) the types, extent and causes of delays and other unproductive time; and (3) production rates of different sizes of lines. 3/

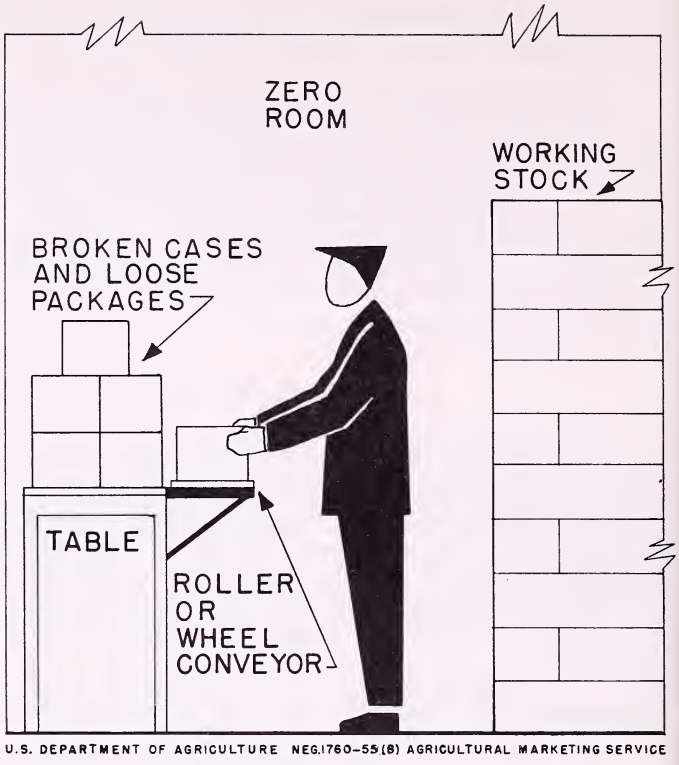

Figure 1.--A roller, or wheel, conveyor is used in zero room to assemble orders.

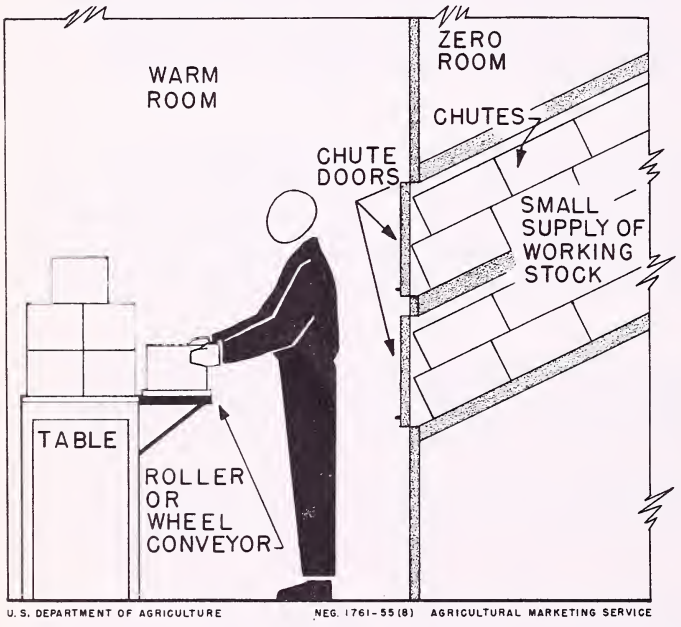

Figure 2.--Order-assembly operations in a warm room. The chutes are loaded with merchandise from the zero rooms.

Figure 3 shows the operations involved in assembling individual frozen food orders, including the loading of delivery trucks. In a preliminary study of 5 plants, an average of only 25 percent of the labor time was devoted to order filling. Checking, marking, and other paper work accounted for 22 percent of the labor time, and truckloading for 71 percent.

Figure 3 also shows that an average of only 71 percent of the total hours of labor employed in assembling orders and loading delivery trucks in the 5 plants studied was devoted to productive work. The remaining 29 percent of this labor time was unproductive. One of the chief causes of the unproductiveness was that order fillers at various work stations along the line, who were responsible for adding certain items to individual orders, waited either for the preceding or

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3/ For a discussion of research methods and techniques used, see the Appendix.

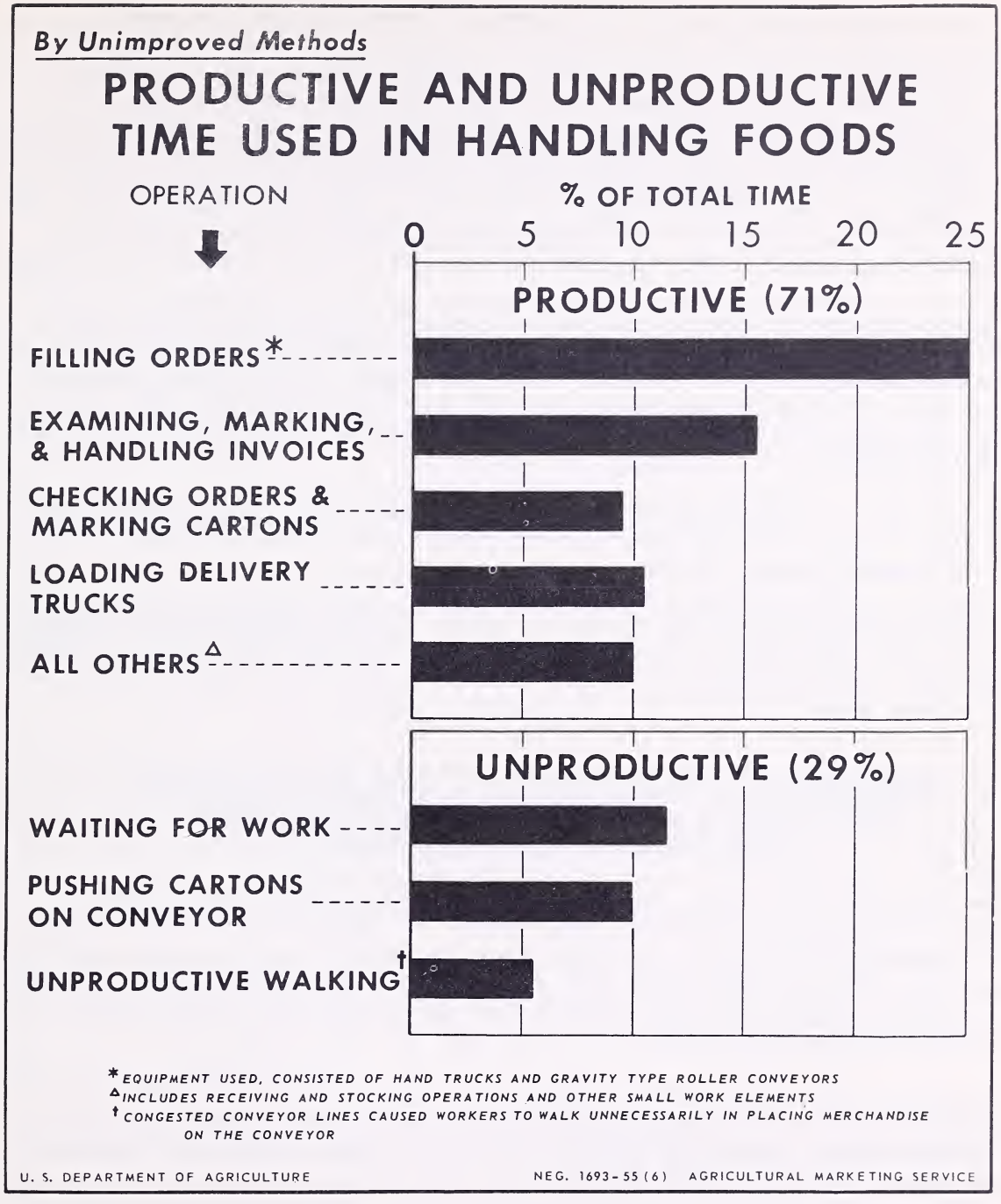
By Unimproved Methods
PRODUCTIVE AND UNPRODUCTIVE TIME USED IN HANDLING FOODS
OPERATION
% OF TOTAL TIME
0
5
10
15
20
25
PRODUCTIVE (71%)
FILLING ORDERS*
EXAMINING, MARKING, & HANDLING INVOICES
CHECKING ORDERS & MARKING CARTONS
LOADING DELIVERY TRUCKS
ALL OTHERS△
UNPRODUCTIVE (29%)
WAITING FOR WORK
PUSHING CARTONS ON CONVEYOR
UNPRODUCTIVE WALKING†
*EQUIPMENT USED, CONSISTED OF HAND TRUCKS AND GRAVITY TYPE ROLLER CONVEYORS
△INCLUDES RECEIVING AND STOCKING OPERATIONS AND OTHER SMALL WORK ELEMENTS
†CONGESTED CONVEYOR LINES CAUSED WORKERS TO WALK UNNECESSARILY IN PLACING MERCHANDISE ON THE CONVEYOR
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Figure 3

originating station to complete its work and push the incomplete order into their respective stations. This delay time accounted for 13 percent of the total labor time. Manually pushing the cartons or cases comprising individual orders along the conveyor line from one work station to the next--an operation that would require no labor if powered conveyors were used--was considered as unproductive work. This operation accounted for 10 percent of the total labor employed. Delays in moving individual orders from one work station to the next caused congestion along the line which made it necessary for order fillers to do considerable walking to place items at the proper sequence on the conveyor line. The time required for walking that could be avoided by better organization was considered unproductive. This accounted for 6 percent of the total labor time employed.

In the development of new work methods and equipment, the primary objective was to minimize delays and other unproductive time by: (1) More equally dividing the workload at the various stations; (2) substituting power for manual labor to move cartons and cases from one work station to the next station; and (3) providing more adequate work space on the line and a more efficient stocking arrangement to minimize congestion on the line and unproductive walking.

In an effort to accomplish these objectives, a portable power roller conveyor unit was developed and tested in one plant. A description of this unit and the results of the tests are presented in one of the sections that follow.

Another method developed and tested in an effort to reduce equipment costs involved the use of carts. Both single- and multiple-deck carts were tested. Descriptions of this equipment and the methods employed, together with the results of the tests, also are presented in this report.

CASE STUDY NO. 1--SUBSTITUTION OF A POWER ROLLER CONVEYOR, FORKLIFT TRUCK, AND PALLETS FOR GRAVITY-TYPE ROLLER CONVEYORS AND 4-WHEEL HAND TRUCKS

The wholesale frozen food distribution plant in which this case study was made is in a public refrigerated warehouse. The plant handles 275 different frozen food items and sells an average of 2,000 cases daily. This volume is assembled into an average of 350 individual orders which are loaded onto 9 delivery trucks. At the time the study was initiated the plant used a gravity-type roller conveyor line. Occasionally the cartons jammed up, or had to be pushed along the conveyor.

To overcome some of the defects, a power roller conveyor line was designed, installed, and tested in the plant. Simultaneously, a forklift truck and pallets were installed to replace 4-wheel hand trucks. The new system involved a complete change of operation, as well as complete renovation of the plant.

Equipment, Facilities, and Work Methods Before Improvements Were Made

Gravity-Type Roller Conveyor Order Assembly Line

Before improvements were made the plant used a modified dual order assembly line consisting, in part, of 2 parallel 50-foot lines of 12-inch-wide gravity-type roller

conveyor lines which were connected by a curved section at the end nearest the truckloading docks. An extension of one of these conveyor lines bridged the distance from the end of the line to a point midway of the delivery truck body. The two conveyor lines were separated by a 4-foot worktable which extended the length of the conveyors and was used for the temporary storage of broken or split cases and loose packages of frozen foods. For operational purposes the order assembly line was divided into 4 order filling stations, each of which was roughly 25 feet long, and one order checking station.

Layout of the Plant

Before the changeover to the power conveyor system, the plant consisted of two rooms (fig. 4). One room, 20 by 80 feet, was held at 0° F. It was used for storing the working stocks. Along part of the wall which separated this room from the second room were a series of 40 8-foot-deep chutes. These chutes emptied into the second or adjoining room. This room, 20 by 60 feet, was held at between 30° and 40° F. and used for order assembly operations. The gravity-type conveyor line was placed lengthwise through the center of this room. Both rooms had a ceiling height of 10 feet and together they contained a total of approximately 28,000 cubic feet of space. The capacity of the zero room, after deducting for aisles, chutes, and clearances, was approximately 8,000 cases, or a 4 days' inventory.

Cases of frozen food were moved from the zero room to the warm room by means of the 40 chutes which were equipped with doors that opened into the warm room. The warm room was the center of the order assembly operations and is shown to the left of the zero room in figure 4.

Methods of Operation

During the day, 3 workers using 4-wheel hand trucks received and moved merchandise into the storage room, stocked the 40 chutes, and performed other utility jobs. Merchandise was received on 4-wheel hand trucks from the refrigerated warehouse at aprons outside the freezer room door. Cases of frozen foods were manually removed from the hand trucks and stacked in the reserve stock area. Four-wheel hand trucks also were used by the 3-man crew for moving cases from the stockpiles to the chutes in the stocking operation.

The night crew consisted of 8 workers--4 order fillers, 1 checker, 1 truckloader, 1 worker who restocked chutes, and 1 foreman. Two order fillers were assigned to each line, and each order filler was assigned responsibility for the items along roughly 25 feet or one-half the line. The order checker was stationed at the end or the convergence of the 2 lines to check assembled orders.

Invoices were grouped by truck routes. Order filling began at the first station where the order filler examined the invoice, determined the items and amounts of each required from his station, and started removing these items from the chutes. Full cases were placed on the conveyor and marked with the order and route numbers. In assembling items in less-than-case quantities, a full carton was removed from its storage position, placed on the conveyor, opened, and the required number of packages were either removed and placed in an empty container or in a previously opened but partly filled case. Opened cases from which only a part of the packages were removed were placed on the worktable for later use. Containers of less-than-case quantities were also marked with the order and route numbers. This cycle was repeated until all items stocked in station 1 had been assembled. The invoice

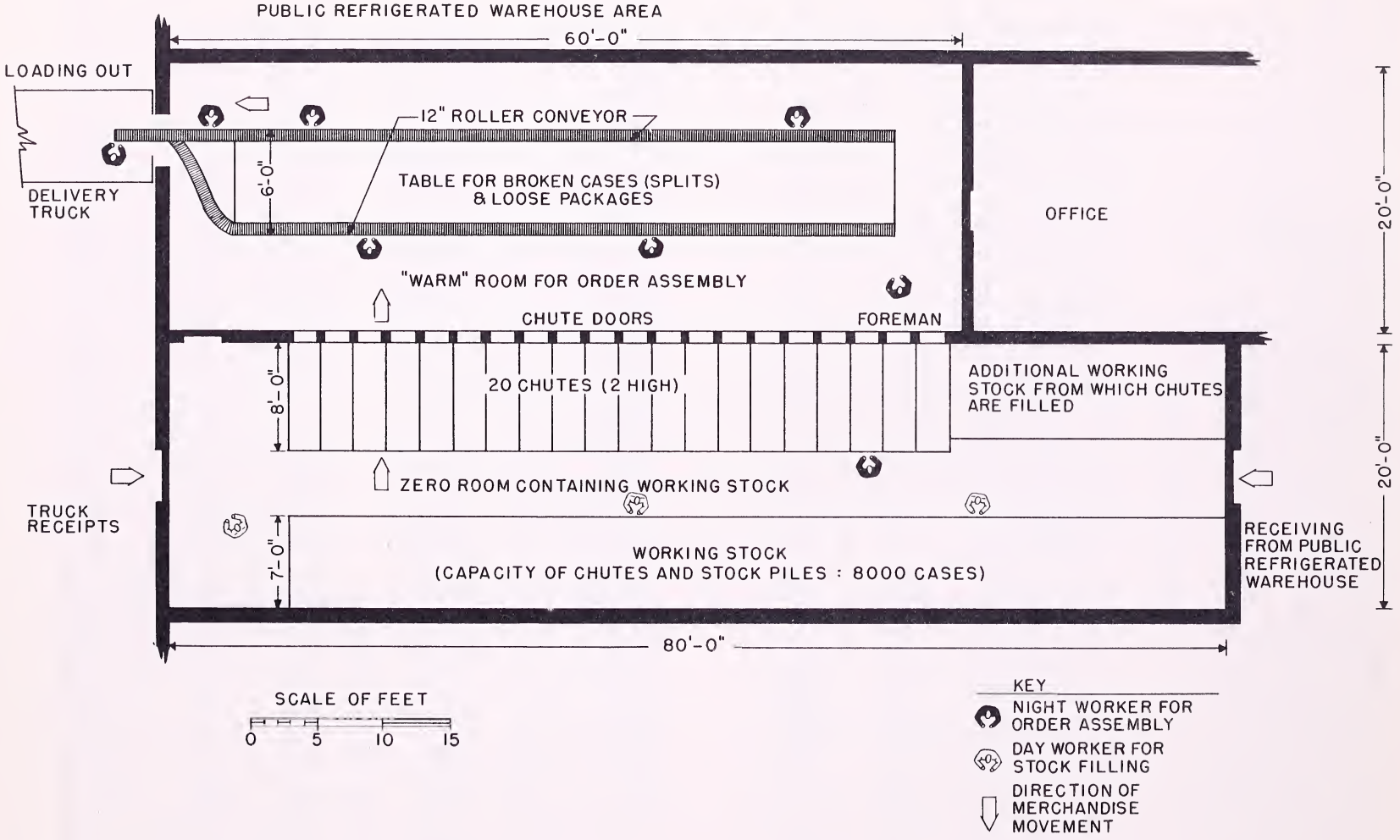

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Figure 4.--Layout of pilot plant (located in a public refrigerated warehouse) before converting to palletized receiving and a power roller conveyor system for order assembly.

then was placed on the first or leading case, all cases were pushed into the second station, and the order filler in station 1 began the assembly of another order. In station 2 the operation continued as in station 1 until the order had been completely filled and all cases were pushed to the checker at the end of the line. After being checked, the cases and cartons were pushed over the conveyor into the delivery truck.

One worker in the delivery truck removed the merchandise from the conveyor and stowed it in the truck. Throughout the order assembly operation, a seventh worker, who was stationed in the storage room, replenished the chutes with full cases of merchandise. The eighth member of the night crew was the foreman who supervised all operations.

Labor Requirements and Productivity

The total daily labor requirements for handling 2,000 cases a day of frozen foods into, within, and out of the plant were 88 man-hours or an average of slightly more than 0.25 man-hour per order. This includes both productive and unproductive labor and the supervisory work involved.

The results of a work sampling study of order filling and truckloading operations made in this plant are shown in table 1. The total unproductive time of 28 percent is accounted for by delays on the part of order fillers waiting for work, pushing cartons on the conveyor line from one work station to the next station, and unproductive walking. To increase efficiency, methods were devised for reducing unproductive time. The new system provides a solution to this problem, as shown in the following section of this report.

Table 1.--Percentage distribution by specified operations of the labor time of an 8-man crew employed in a selected wholesale frozen food plant for filling orders and loading delivery trucks by use of a gravity-type conveyor line

Operation	Distribution of work time as a percent of total time	
	Productive	Unproductive
	Percent	Percent
1. Filling orders	26.0	
2. Examining, marking, and handling invoices	15.5	
3. Waiting for work (delay time)		12.5
4. Pushing cartons on conveyor		11.0
5. Unproductive walking		4.5
6. Checking orders and marking cartons	9.5	
7. Loading delivery trucks	9.0	
8. All other 1/	12.0	
Total	72.0	28.0

1/ Includes 12 small work elements and night restocking of chutes.

Equipment, Facilities, and Work Methods After Improvements Were Made

Power Roller Conveyor Order Assembly Line

The improved conveyor-type order assembly line operated as follows: (1) Power roller conveyors, which moved cases of frozen foods from one work station to another without manual effort, were substituted for gravity-type roller conveyors (the latter were retained to provide a working surface only). (2) The workload at each station was equalized by increasing or decreasing the number of frozen food items assigned. (3) The length of the line was increased to minimize *jamming up* of orders and the consequent unproductive walking required to place cases in proper sequence. (4) The entire line was constructed as a portable unit to permit the maximum utilization of storage space and the most efficient use of a straddle-type industrial forklift truck.

The prototype power roller conveyor consists, in part, of 2 parallel 75-foot lengths of 18-inch-wide powered roller conveyors. The live rollers are 2 inches in diameter, 15 inches long, and set on 3-inch centers. The roller conveyors, which are geared to operate in opposite directions, are powered through friction of a 12-inch-wide belt running between the carrier roller on the top side of the conveyor line and supporting rollers below the belt (fig. 5).

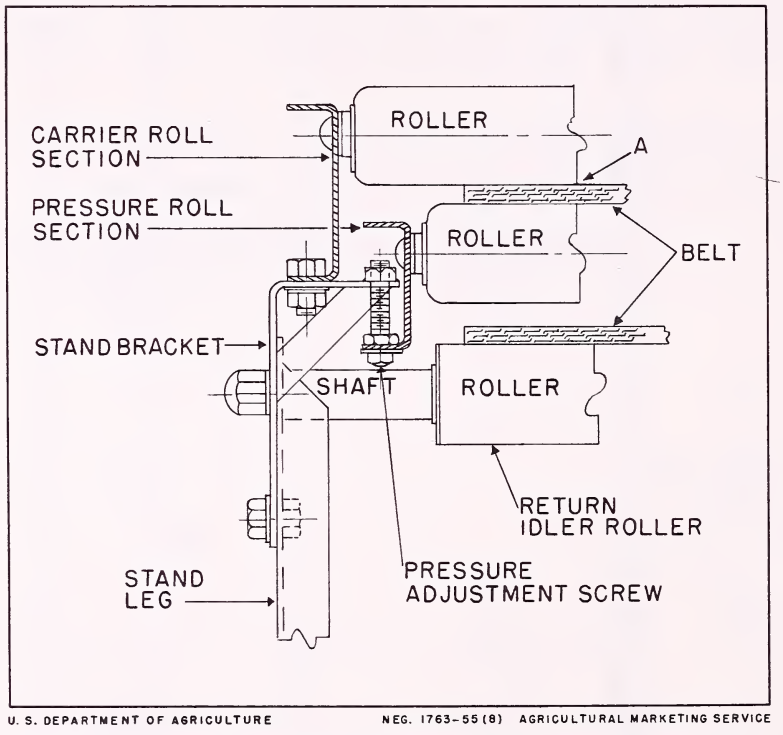

Figure 5.--Cross section through rollers showing pressure roller transmitting power by causing the belt to turn the carrier roller, at point 'A' above.

The two powered conveyors are connected at one end by a rotary-type powered transfer table (fig. 6). For operational purposes, this connection of the 2 lines (which move in opposite directions) provides a single line of 150 feet rather than dual lines of 75 feet each.

To provide adequate working surface for splitting cases and packing less-than-case-lot items, 12-inch gravity-type wheel conveyors are hinged alongside the full length of each of the power roller conveyor lines. When in *up* position these conveyors are 29 inches above the floor. Space for stacking broken cases, empty cartons and loose packages was provided by a table constructed 20 inches above the 2 power conveyor lines. This table, which is roughly 44 inches wide, extends the full length of the conveyor (fig. 7).

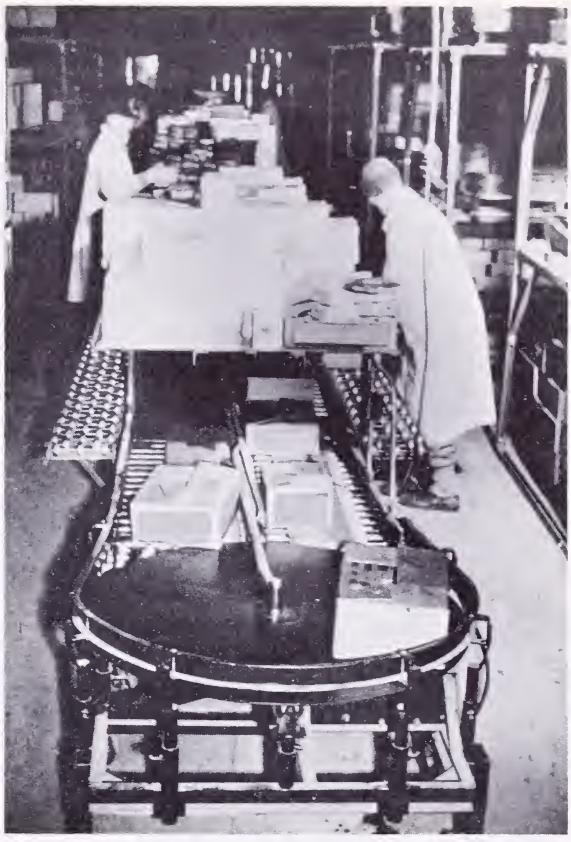

Figure 6.--Transfer end of the power roller conveyor, showing side-hinged wheel conveyors in 'up' position.

The new power roller conveyor was constructed as a unit and mounted on casters, so that it can be moved to provide a wider aisle while merchandise is being placed in the working stock. During receiving periods, the hinged gravity-type conveyors can be placed in the *down* position to give even greater aisle space. This line was divided into 4 order-filling stations and 1 order-checking station. The latter station was connected with the delivery truck being loaded by a section of gravity-type roller conveyor.

Layout of the Plant

To accommodate the new equipment and provide additional storage space, the partition and chutes between the zero and warm rooms were removed and additional space was leased from the refrigerated warehouse. This changeover converted the order assembly room from a warm room to a zero room. The power roller conveyor unit was installed in a room approximately 40 feet wide and 100 feet deep (fig. 8). As its ceiling height is 15 feet, the room contains 60,000 cubic feet of space. The net storage capacity of the room, after deducting for aisles and clearances, is approximately 30,000 cases--or a 15-day inventory. A 10-foot center aisle was provided lengthwise of the room for the power roller conveyor unit, and for the operation of the forklift truck, leaving 15 feet of storage space on each side of the aisle. Lateral, or side, aisles were laid out perpendicular to the center aisle so as to provide a direct line of travel to and from the power roller conveyor, and to provide aisle frontage for a maximum number of items. The lateral aisles are 6 feet 2 inches wide, which is sufficient space for the operation of a straddle-type forklift truck.

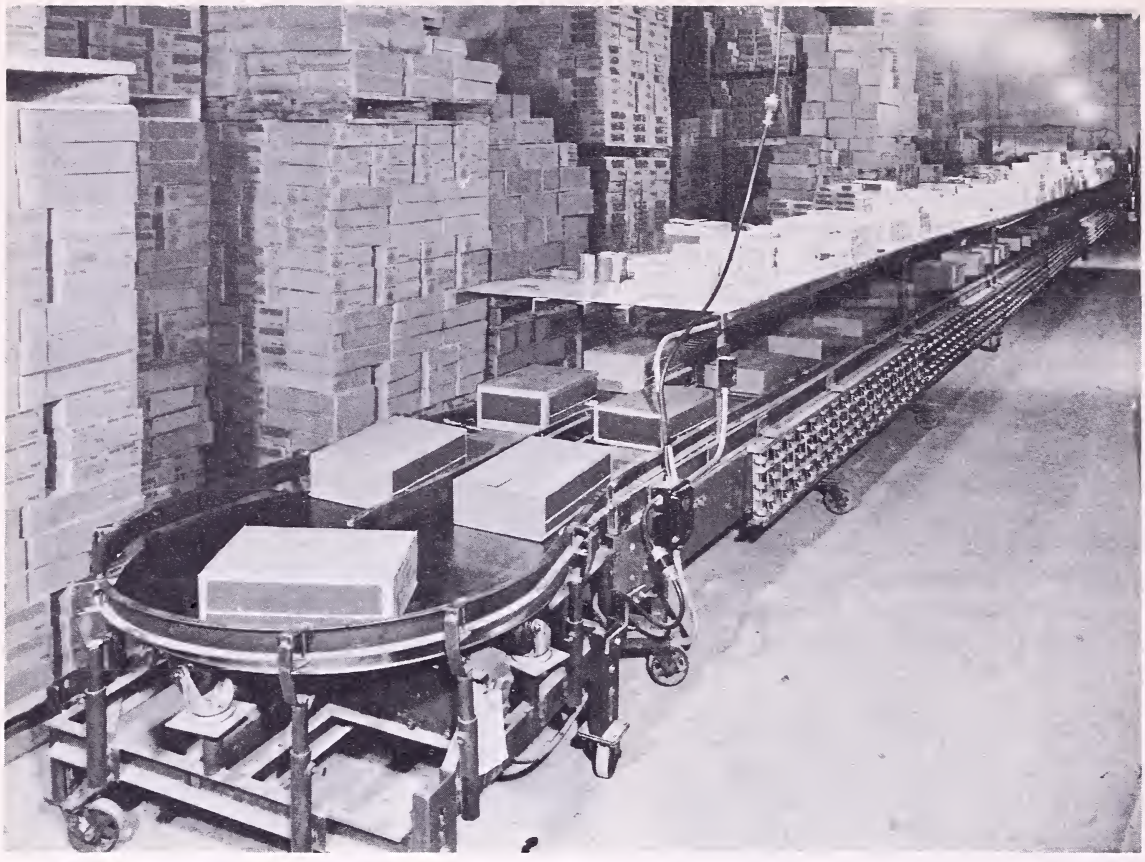

Figure 7.--A power roller conveyor unit for assembling frozen food orders. Note the side-hinged wheel conveyors in the 'down' position, the wide tabletop working surface, and the transfer table for transferring packages from one conveyor to the other. The unit has been pushed to one side of the aisle to provide additional space for the straddle-type forklift truck.

As the merchandise was to be stored on 36- by 48-inch pallets, most of the storage bays were laid out 2 pallets or 6 feet wide from one lateral aisle to the next aisle. Seven-foot-high pallet racks were placed in 7 of the storage bays so that the *cube* or net storage space of the room could be fully utilized (fig. 9). This height was adopted because normally a worker cannot reach much higher than 7 feet without straining and inducing extra fatigue. Some of the racks were constructed with 2 pallet tiers. Others were made with several sets of shelves for hand stacking. The 2-tier racks were built to store 2 palletized unit loads of the same size. The multiple-shelf racks were designed for slow-moving items. All racks had ample structural strength to permit merchandise to be stacked in pallet loads on top. Where possible, racks were installed in double section, back to back, to increase their stability. Single sections were used against walls and were anchored to the floor.

Merchandise was arranged in storage bays so that similar categories of items were placed together. That is, all vegetables were placed in one section, fruits in another, etc. The highest-volume items in each category were placed nearest the main aisle. Slower-moving

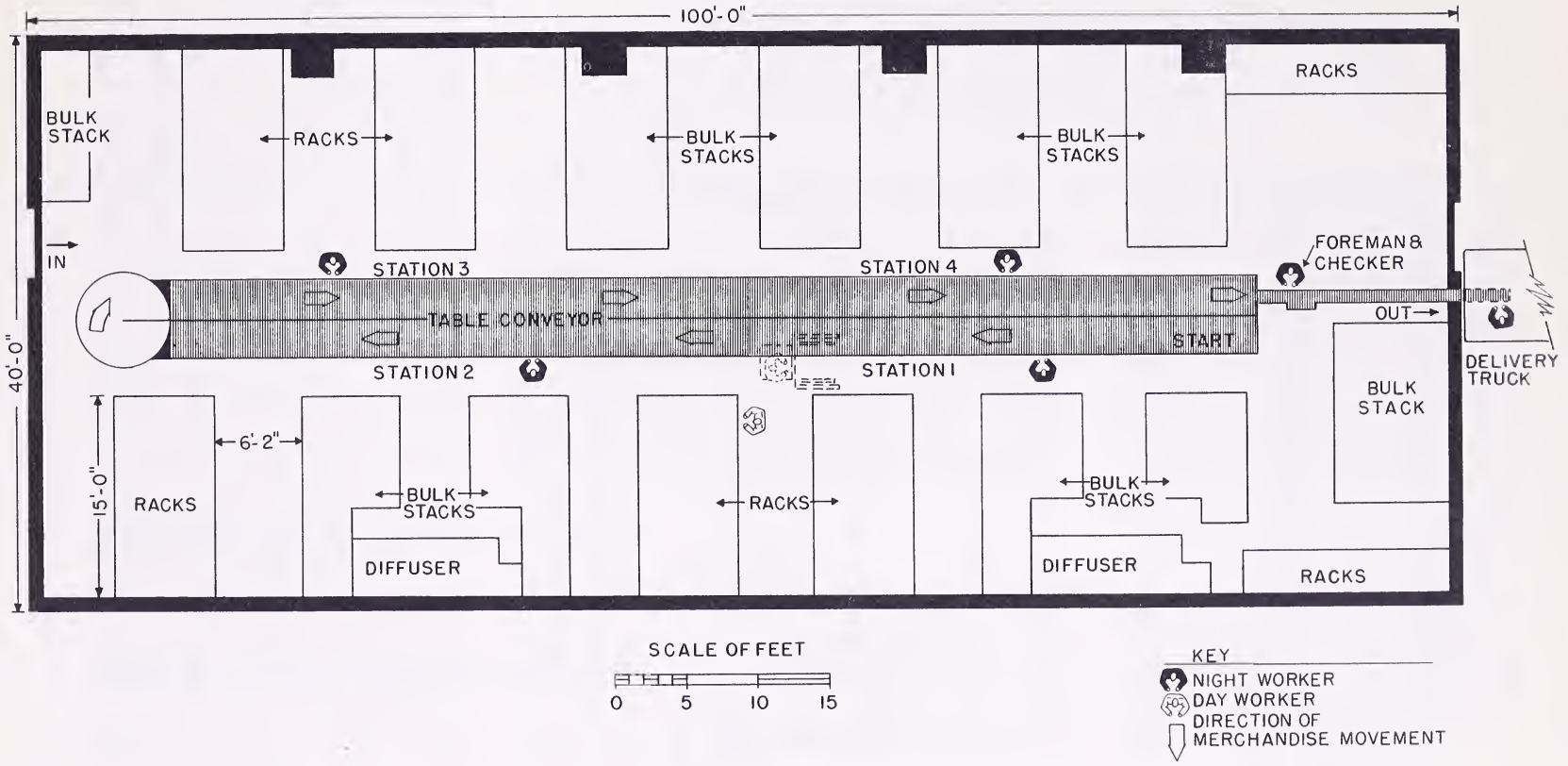

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Figure 8.--Layout of order assembly and storage room for power roller conveyor. Merchandise is palletized and stocking is by a straddle-type forklift truck that operates in a 6-foot 2-inch wide aisle.

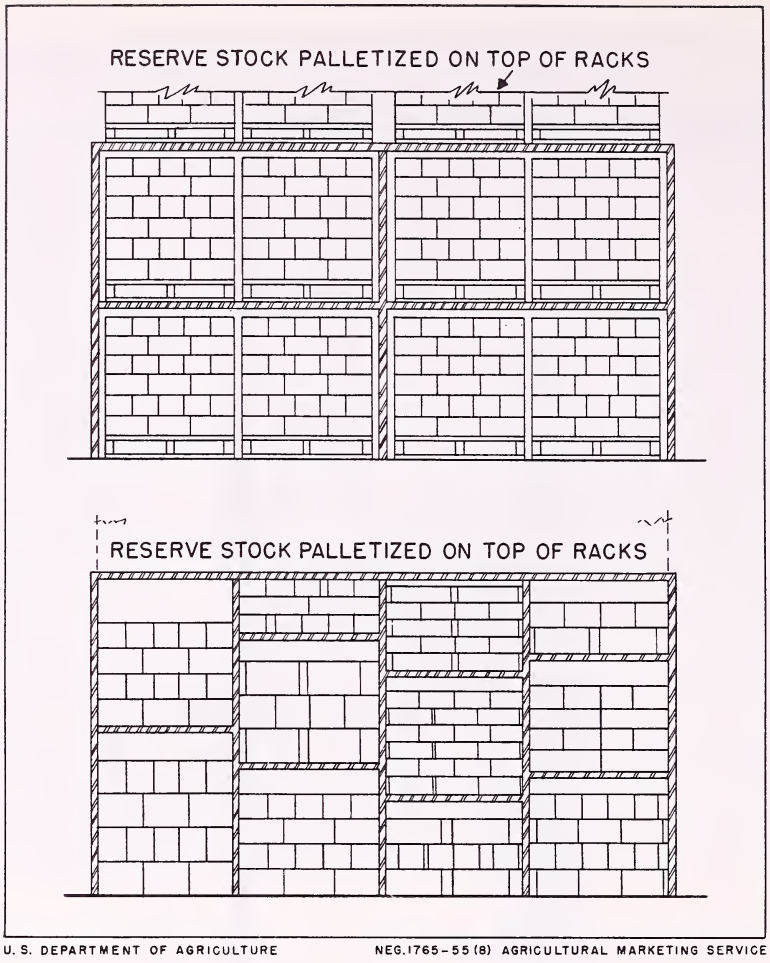
RESERVE STOCK PALLETIZED ON TOP OF RACKS
RESERVE STOCK PALLETIZED ON TOP OF RACKS
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Figure 9.--Pallet racks (top) and adjustable multiple-shelf racks for hand stacking. Merchandise is palletized on floor of racks constructed mainly for hand stacking. Shelvings on all racks are adjustable and removable.

items were placed higher off the floor than the fast-moving items. The arrangement of the power conveyor unit in relation to storage racks is shown in figure 10. As juices and vegetables were the fastest-moving items in the retail line and usually were sold in case lots, these items were assigned space near the *exit* end of the assembly line where they would be the last items to be placed on the conveyor. This was done so that these items would be handled fewer times and would not cause *loading up* of the conveyor. Some of the low-volume items were intermingled with high-volume items throughout the room in order to achieve a balanced workload among order assembly stations. The storage of items was arranged so that the workload at station No. 1, where invoices on all orders are started, was made lighter than that of other work stations in order to provide a continuous flow of orders to the other stations. In assigning categories of items to work stations, consideration was given to the fact that the amount of work required in filling an order often is in reverse relationship to the sales volume for the item. The reason for this is that high-volume

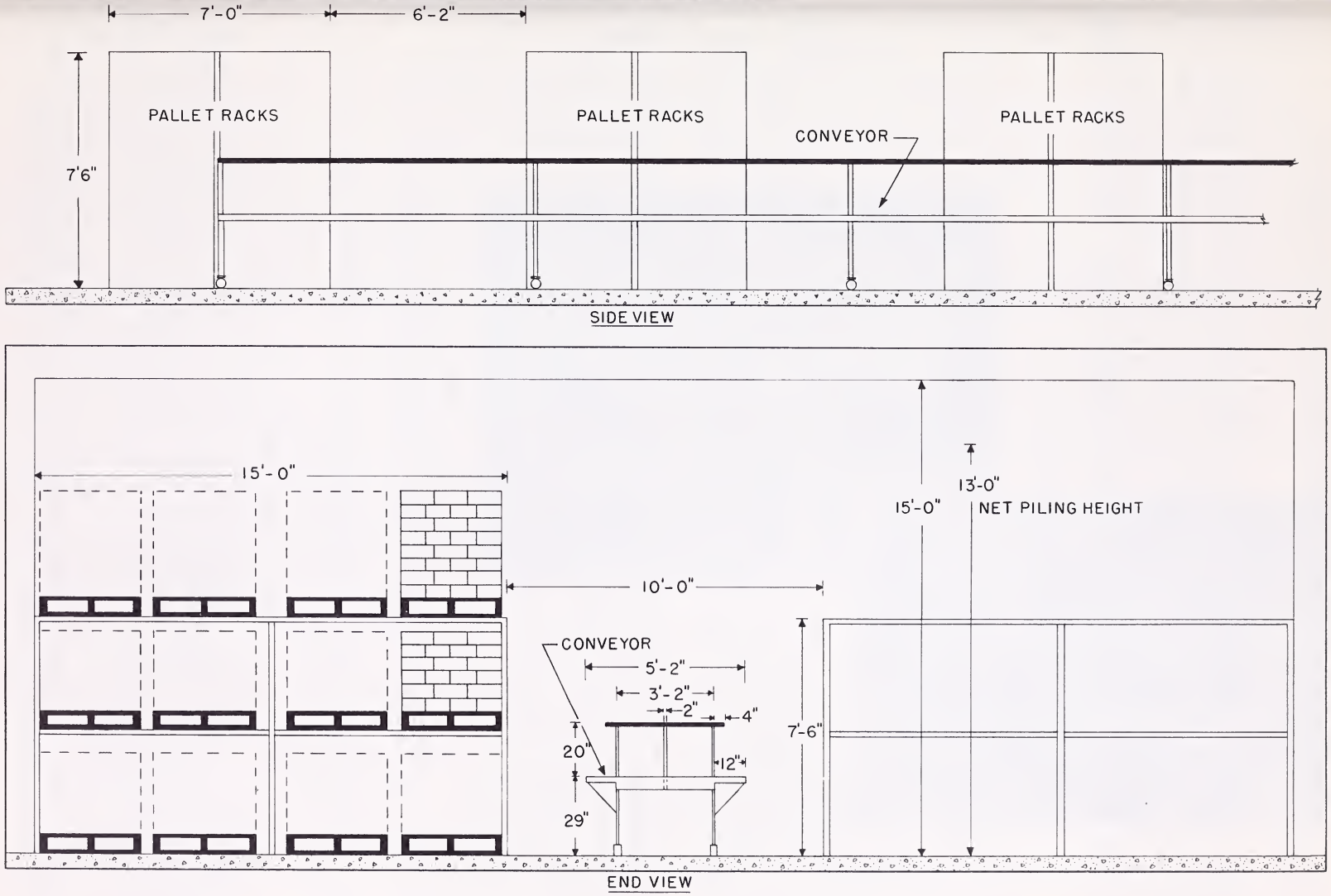

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Figure 10.--Arrangement of the improved order assembly room showing relationship of power conveyor to storage racks.

items frequently are sold in case lots and low-volume items frequently require a considerable amount of repacking.

The initial storage arrangement of items in the order assembly room was determined by sales volumes, using weekly or monthly sales figures. Institutional items were placed in a separate work station from retail items, because orders for the institutional items could be filled more rapidly from a single storage area. Each institutional order was loaded onto the conveyor in its proper sequence at the end of the line. Frozen food items were listed on the invoices to correspond with their arrangement in the order assembly room.

Methods of Operation

Most of the merchandise received by the frozen food plant is delivered from the storage rooms of the refrigerated warehouse in which it is located. Deliveries are made by the warehouse crews to the receiving apron of the order assembly room. However, a small volume received by motortruck is unloaded directly into the plant's order assembly room. Most of the volume received from the warehouse is in pallet loads. Deliveries by the warehouseman are made after 10 a.m. when order filling operations have been completed. As soon as the residual working stock in the room has been adjusted (lots combined) for receiving, the merchandise is brought in and stowed in assigned locations (fig. 11). This work is done by 2 workers--a forklift truck operator and a utility man. A considerable amount of reserve stock is kept on top of the racks and this merchandise also is used to replenish working stocks in the pallet racks. A total of about 11 man-hours daily is required for the receiving and stocking operations. The remaining 5 of the 16 man-hours is devoted to other work.

Items are assigned to specific locations, and care is exercised in putting working stock in assigned spaces to facilitate order selection and to aid in receiving and inventory control. By the inventory control system, which is maintained on punchcards, a space factor is applied which establishes the maximum quantity to be carried in working stocks, commensurate with the assigned space and the volume on hand. This practice reduces rehandling of merchandise, establishes a minimum inventory based on the rate of movement of each item, and permits the palletization of a maximum number of items. Before order assembly operations are started, punchcards are pulled and put into the invoice writing machines in the same sequence in which the items are stacked in the order assembly room. If preprinted invoices are used, they must be printed to conform to the layout of merchandise in the room. Individual items within each category, however, appear on the invoice in alphabetical order.

The night crew for order assembly operations consists of 6 workers--4 order fillers, 1 of whom checks orders, 1 truckloader, and 1 foreman.

Order assembly with the power roller conveyor operates as follows: The order filler at station No. 1, who is assigned a specific number of frozen food items, starts each order off on the journey around the assembly line by putting onto the power roller conveyor the items called for from his station. After all items in his station are on the conveyor, a clipboard holding the invoice is placed on the last carton placed on the conveyor. If no items are called for from another station, the clipboard with the invoice is put directly on the power roller conveyor.

The partly filled order, or the clipboard, is conveyed to station No. 2, where it is stopped by a bar across the rollers (fig. 12). After the worker at station No. 2 has

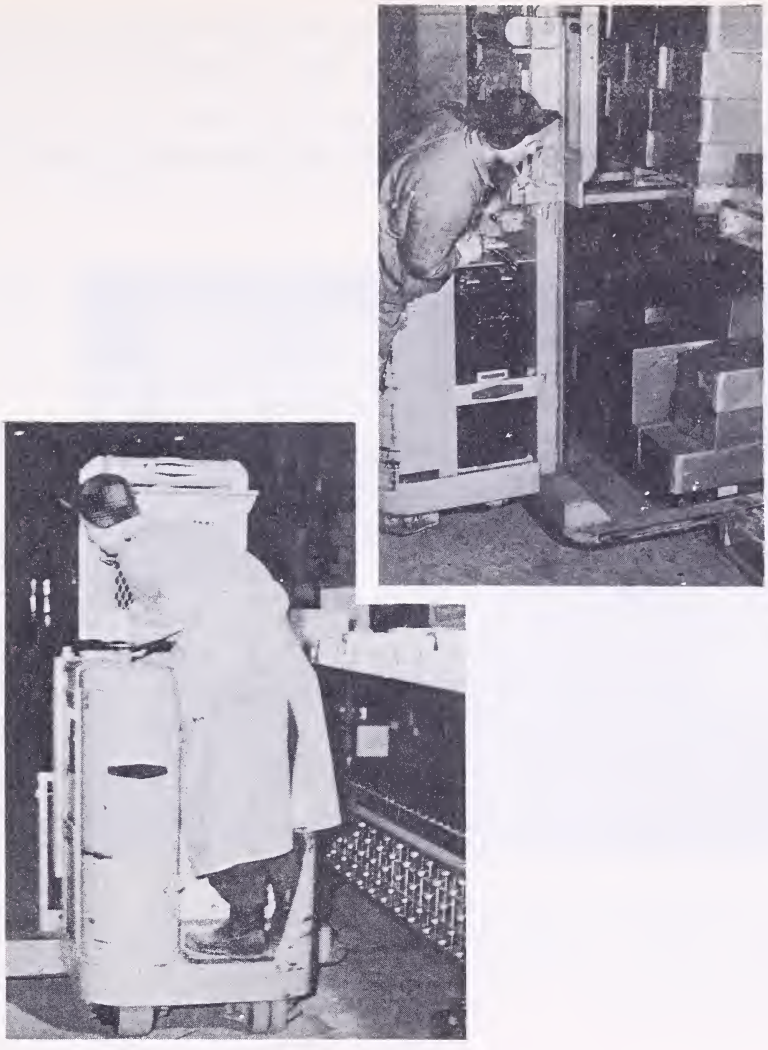

Figure 11.--In stocking the order assembly room with straddle-type forklift truck, the hinged wheel conveyors attached to the side of the table conveyor unit are lowered as shown on the right side of the lower picture. The table-conveyor unit which is mounted on casters can be pushed to either side of the central aisle to permit more aisle space during stocking.

completed his part of the previous order and placed the clipboard for that order on the last carton, he lifts the stop bar and permits the next order to flow into his station. He removes the clipboard from the last carton as it moves past and places a stop bar across the conveyor behind the last carton, or in front of the first carton of the next order. He fills the order from the clipboard, placing the merchandise in front of the stop bar. Thus, all the merchandise contained in an order remains together as it proceeds along the conveyor line.

This cycle of operations is repeated at each of four order filling stations. In station No. 4, which is at the end of the line, the order is checked by the fourth worker, who has a light order assembly load. The orders are then conveyed into the delivery truck. A worker stationed in the truck off-loads the conveyor and stacks the merchandise. As the invoices were placed in route order prior to assembly, the orders come off the line into the truck in the desired delivery sequence.

Figure 12.--Stop bar in position (arrow) across power roller conveyor, holding next order. The wheel conveyor and the tabletop are being used as work surfaces for repacking cartons.

Labor Requirements and Productivity

The results of a work sampling study of order filling and truckloading operations after improvements were made are shown in table 2. When the power roller conveyor line was used, the time spent filling orders was increased from 26 percent to 48 percent. Waiting for work was reduced from 12.5 percent to 7 percent and pushing cartons on conveyor lines from 11 percent to 3 percent. Unproductive walking by order fillers was eliminated.

The total daily labor requirements for handling the 2,000 cases of frozen foods were reduced from 88 man-hours to 64 man-hours, or from roughly 0.25 man-hour per order to slightly under 0.17 man-hour.

Comparison of the Old and New Handling Systems

The comparative annual costs of receiving, order assembly, and truckloading operations by the old and new handling systems are shown in table 3. The total annual saving on the

4 items of cost shown is roughly $7,850. The average cost per order by the old handling system was $0.578. By the new system, this was reduced to $0.488, a saving of about $0.09 per order.

With annual savings of approximately $7,850 it is possible to pay for the new equipment, which cost $12,725, in less than 2 years.

Table 2.--Percentage distribution by specified operations of the labor time of a 6-man crew employed in a selected wholesale frozen food distribution plant for filling orders and loading delivery trucks by use of a power roller conveyor line

Operation	Distribution of work time as a percent of total time	
	Productive	Unproductive
	Percent	Percent
1. Filling orders	48	
2. Examining, marking, and handling invoices	13	
3. Waiting for work (delay time)		7
4. Pushing cartons on conveyor		3
5. Unproductive walking		0
6. Checking orders and marking cartons	5	
7. Loading delivery trucks	14	
8. All other 1/	10	
Total	90	10

1/ Includes about 15 small work elements.

Table 3.--Comparative annual costs of 2 methods of handling and storing frozen foods in a wholesale distribution plant filling an average of 350 orders aggregating 2,000 cases daily 1/

Method and equipment	Crew size	Labor	Equipment	Storage charges	Rent	Total
	Number	Dollars	Dollars	Dollars	Dollars	Dollars
Old method: During day 3 workers receive merchandise and stock chutes by 4-wheel hand trucks. During night 4 workers fill orders on gravity-type conveyor line, 1 worker checks orders, 1 worker replenishes chutes, 1 worker stows orders in delivery trucks, 1 foreman	11	2/ 33,000.00	3/ 229.80	4/ 11,800.00	5/ 5,600.00	50,629.80
New method: During day 2 workers receive merchandise and restock order assembly room by straddle-type forklift truck. During night 4 workers fill and check orders on power conveyor line, 1 worker stows orders in delivery trucks, 1 foreman	8	6/ 24,000.00	7/ 2,650.59	8/ 4,130.00	9/ 12,000.00	42,780.59
Savings	3	9,000.00	-2,420.79	7,670.00	-6,400.00	7,849.21

1/ Based on 250 days of operation a year.
2/ 22,000 man-hours (88 man-hours per day for 250 days) at an average rate of $1.50 per hour.
3/ Three 4-wheel hand trucks 6,000 machine-hours at $0.0063 per hour $37.80; 12 10-foot sections of gravity roller conveyor 24,000 machine-hours at $0.008 per hour $192.00.
4/ Figure obtained through accounting analysis.
5/ 28,000 cubic feet of space at an annual rental of $0.20 per cubic foot.
6/ 16,000 man-hours (64 man-hours per day for 250 days) at an average rate of $1.50 per hour.
7/ Forklift truck 2,000 machine-hours at $0.409 per hour $818.00; power roller conveyor 2,000 machine-hours at $0.512 per hour $1,024.00; 300 36- by 48-inch pallets 300 hours of use in actual handling operations (excluding storage) at $1.3953 per hour $418.59; 120 feet pallet racks 2,000 hours of use at $0.195 per hour $390.00.
8/ Annual estimate based on 1 month's operation.
9/ 60,000 cubic feet of space at an annual rental of $0.20 per cubic foot.

CASE STUDY NO. 2--SUBSTITUTION OF SINGLE-DECK CARTS, FORKLIFT TRUCK, AND PALLETS FOR GRAVITY-TYPE ROLLER CONVEYORS, CHUTES, AND 4-WHEEL HAND TRUCKS

The wholesale frozen food distribution plant in which this case study was made is a group of interconnected 2-story buildings. The first floor only of one building is used as a freezer room. There is no loading platform for the breakup room, which is at street level. The distributor's average daily volume is over 2,000 cases (each case equivalent to 24 packages) which is assembled into roughly 700 to 900 orders. Individual orders average about 10 items each, most of which are in less than case quantities. The distributor uses the automatic punchcard tabulating machine method of writing invoices, thus enabling the order filler to work with order sheets that contain only those items called for in the order.

As previously pointed out, one of the weaknesses of the nonpowered gravity conveyor system of the type used in this plant for assembling orders is the excessive delay time caused by the interdependency of workers. The power roller conveyor, described in the preceding section, overcomes this interdependency to a large extent by lengthening the assembly line, thus providing a backlog of orders from which order fillers work without interruption.

Another method tested in an effort to overcome this defect was to eliminate the conveyor line altogether and replace it with a system in which the order fillers operated independently of one another. This was accomplished by the use of single-deck carts. In the cart system each worker filled a complete order rather than only part of an order as on the conveyor assembly line. In frozen food distribution plants where the necessary working stock is stored in a relatively small room, it should be fairly simple to install and operate a single-deck cart system. However, if the working stock is spread out over a large floor area as it is in grocery and drug wholesale houses, the cart system might be inefficient unless used in combination with a dragline or similar device.

Equipment, Facilities, and Work Methods Before Improvements Were Made

Gravity-Type Roller Conveyor Order Assembly Line

Before changes were instituted as a result of the study of this plant's operations, a warm room was used for order assembly. Extending down the center of the warm room was a table about 4 feet wide and 70 feet long with wheel conveyors mounted on each side giving the table an overall width of 6 feet. Two sections of wheel conveyors extended from each end of the table and passed through doors opening into two delivery trucks that were loaded simultaneously, one at each end of the dock-side room. The zero room was equipped with wheel conveyors which were used for receiving and for supplying merchandise to the chutes used in the order assembly work. No racks or bins were used.

Layout of the Plant

The *old* layout of the case study plant used in the single-deck cart system experiment is shown in figure 13. In some respects it is similar to the old layout of case study plant No. 1. One room, 100 feet long by 30 feet wide and 10 feet high, was held at zero (0° F.) temperature and was used for storing the company's working stock. Along one wall was a series of 60 chutes (30 chutes, 2-high) through which merchandise was supplied to the order fillers. Adjoining this room, on the chute side, was a warm room used for order assembly. This room was 80 by 15 feet, and had a 10-foot ceiling. The chutes connecting the zero room to the warm room were equipped with doors on the warm room side.

The combined rooms contained 42,000 cubic feet, which at an assumed rate of 20 cents per cubic foot, had an annual rental value of $8,400. The maximum capacity of the zero room, allowing for aisles, clearances, and chutes, was about 15,000 cases, or less than a week's inventory.

Method of Operation

Handling methods used in this plant before the tests were similar to those used in plant No. 1, before the power roller conveyor was installed. During the day, 6 workers

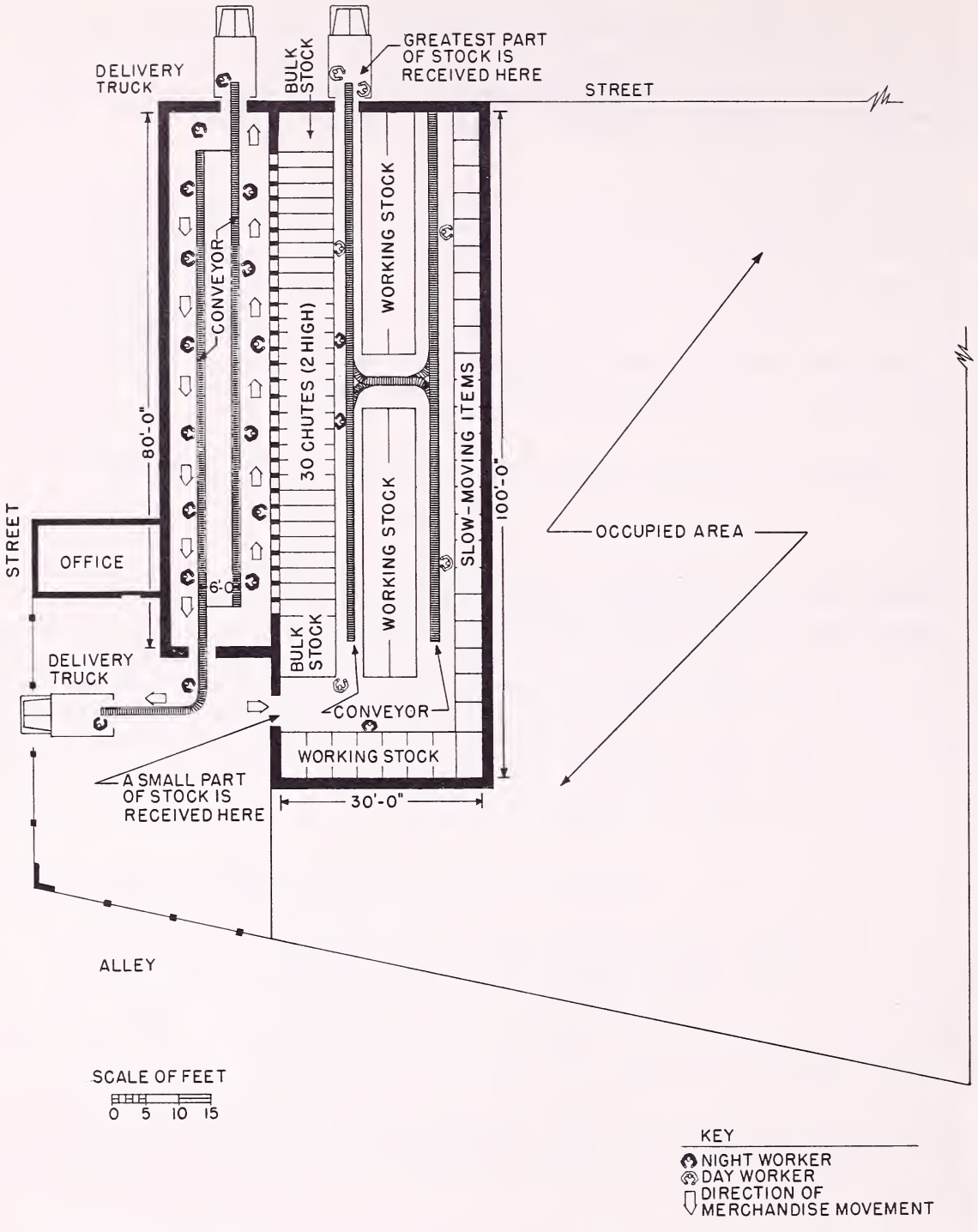

Figure 13.--Layout of a plant showing the old operation, before converting to a palletized receiving and single-deck cart order assembly system.

one of whom is a foreman, moved merchandise into the working stockroom from a receiving apron by means of wheel conveyors. The conveyors in the order assembly and stockrooms were in a fixed position while the entrance conveyor had to be positioned with each shipment received from the warehouse. Orders were assembled at night on an assembly line basis with 6 men on each side of the table. Each man filled part of an order by taking merchandise from the chutes or from the table and pushing it on the wheel conveyor to the next worker. Two checkers were stationed at opposite ends of the table, one serving also as foreman of the night crew. One worker was stationed at each of the 2 delivery truck stations for off-loading the 2 conveyors and stacking the merchandise in the trucks. Two men were stationed in the freezer (zero room) to keep the chutes filled with full cases of merchandise. One man was used independently for filling institutional orders.

Labor Requirements and Productivity

The total daily labor requirements for handling 900 orders into, within, and out of this plant were 200 man-hours, or an average of 0.22 man-hour per order. This includes both productive and unproductive labor and the supervisory work.

The results of a work sampling study of order filling and truckloading made in this plant are shown in table 4. The total unproductive time of 32 percent is accounted for by delays on the part of order fillers waiting for work, pushing cartons on the conveyor line from one work station to the next, and unproductive walking. The single-deck pushcart method was devised for reducing unproductive time.

Table 4.--Percentage distribution by specified operations of the labor time of a 19-man crew employed in a selected wholesale frozen food plant for filling orders and loading delivery trucks by use of gravity-type roller conveyors, chutes, and 4-wheel hand trucks

Operation	Distribution of work time as a percent of total time	
	Productive	Unproductive
	Percent	Percent
1. Filling orders	23	
2. Examining, marking, and handling invoices	16	
3. Waiting for work (delay time)		17
4. Pushing cartons on conveyor		10
5. Unproductive walking		5
6. Checking orders and marking cartons	11	
7. Loading delivery trucks	8	
8. All other 1/	10	
Total	68	32

1/ Includes 12 small work elements.

Equipment, Facilities, and Work Methods After Improvements Were Made

Single-Deck Cart System

Single-deck carts for order assembly were designed to permit the order filler to perform his job at optimum speed. These carts are 50 inches long and either 18, 20, or 24 inches wide. Their widths were varied in order to accommodate different size orders. Lubricated roller bearing wheels are provided to operate with a maximum effectiveness at zero degrees. Wheel rims are of resinoid plastic so they will not stick to the floors in cold rooms nor crack and fall apart because of freezing and thawing conditions. The rear set of caster wheels are of the swivel type, the front set are fixed. The decks are constructed of lightweight but durable material. A writing shelf holds invoices; a push bar located at the writing shelf is easily grasped for maneuvering the cart. A rigid working shelf is provided for repacking cartons (figs. 14 and 15).

Figure 14.--Single-deck carts used for order assembly operations.

Layout of the Plant

The single-deck cart system was installed in a new room 30 feet wide at one end, 45 feet wide at the other, and 70 feet deep (fig. 16). The ceiling height is 12 feet. The rooms previously used in the old system are now used for a part of the reserve supply of frozen food. The remainder of the reserve supply is stored in a nearby public refrigerated warehouse.

The new room contains 32,000 cubic feet of space which, with the 42,000 cubic feet in the old rooms, brings the total to 74,000 cubic feet. At an assumed rate of 20 cents per cubic foot the annual rental value of the facility is $14,800. The total maximum capacity of the new plant, allowing for aisle clearance, is about 37,000 cases.

Although the layout of the order assembly room is not entirely suitable for a single-deck cart operation, it was adequate. In planning the layout, merchandise was arranged so as to obtain enough aisle frontage to permit ready access to all items. Because of the large number of items handled, only the faster-moving items were palletized and these were placed in bulk stock rather than in racks. Racks with from 1 to 3 shelves were used for hand stacking the slower-moving items (fig. 17). In stocking the room, similar items were put together. For example, all vegetables were put in one section, all juices in another, and fruits in still another section. The aisles of the room were arranged to permit an order filler with a cart to cut across the room from one item location to another. The more popular items were placed nearest the entrance and exit doors. The width of aisles was established at 6 feet to enable passing and maneuvering of carts and yet conserve space.

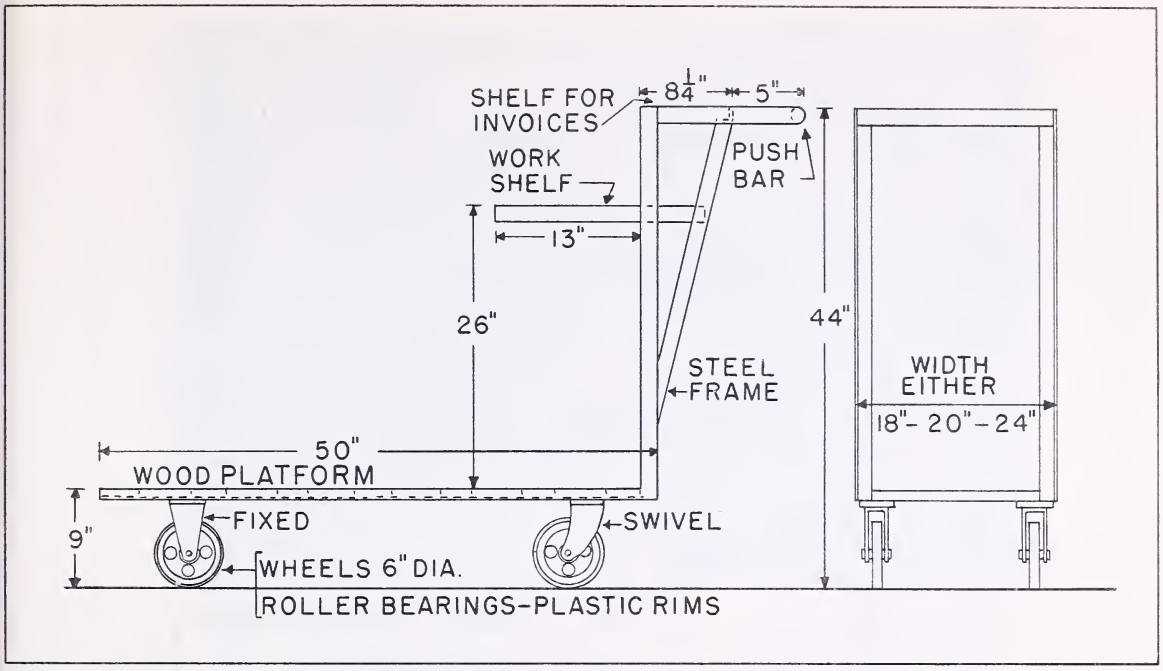

Figure 15.--Major dimensions of a single-deck order assembly cart.

Methods of Operation

In the new system, the receiving of merchandise (a large amount unpalletized) into the working stock during the day is accomplished by 2 men and 1 forklift truck. The faster-moving items are picked up at the receiving apron, transported into the order assembly room and stacked in pallet loads. The slower-moving items are transported into the room on pallets by the forklift truck and hand stacked in racks. Carts are occasionally used for transporting merchandise into the working stockroom.

In the operation of the single-deck cart system, 10 order fillers are used. Each man pushes a cart through the order assembly room, making a round trip. In the case of medium or large size orders he fills only one order at a time, but with small orders he may fill from 2 to 5 orders at a time, depending on the ability of the individual worker. When the worker takes an empty cart from the parking area, it already has 1 or more invoices on the writing shelf. Assigning invoices to carts is done by the supervisor or checker. When the worker returns to the cart parking area with a loaded cart, he immediately picks up an empty cart and repeats the operation. Orders are filled in the sequence in which they are to be loaded into the delivery truck. The items are checked by 1 worker on each of the 2 delivery trucks as they are loaded into the trucks.

In order to have adequate equipment on hand at all times, it was necessary to provide about 35 carts. With fewer carts, order fillers would frequently have been idle.

Two delivery trucks are loaded out simultaneously. Two men work at each truck, loading out the orders from the carts. Because of the small doors on delivery trucks, an aluminum

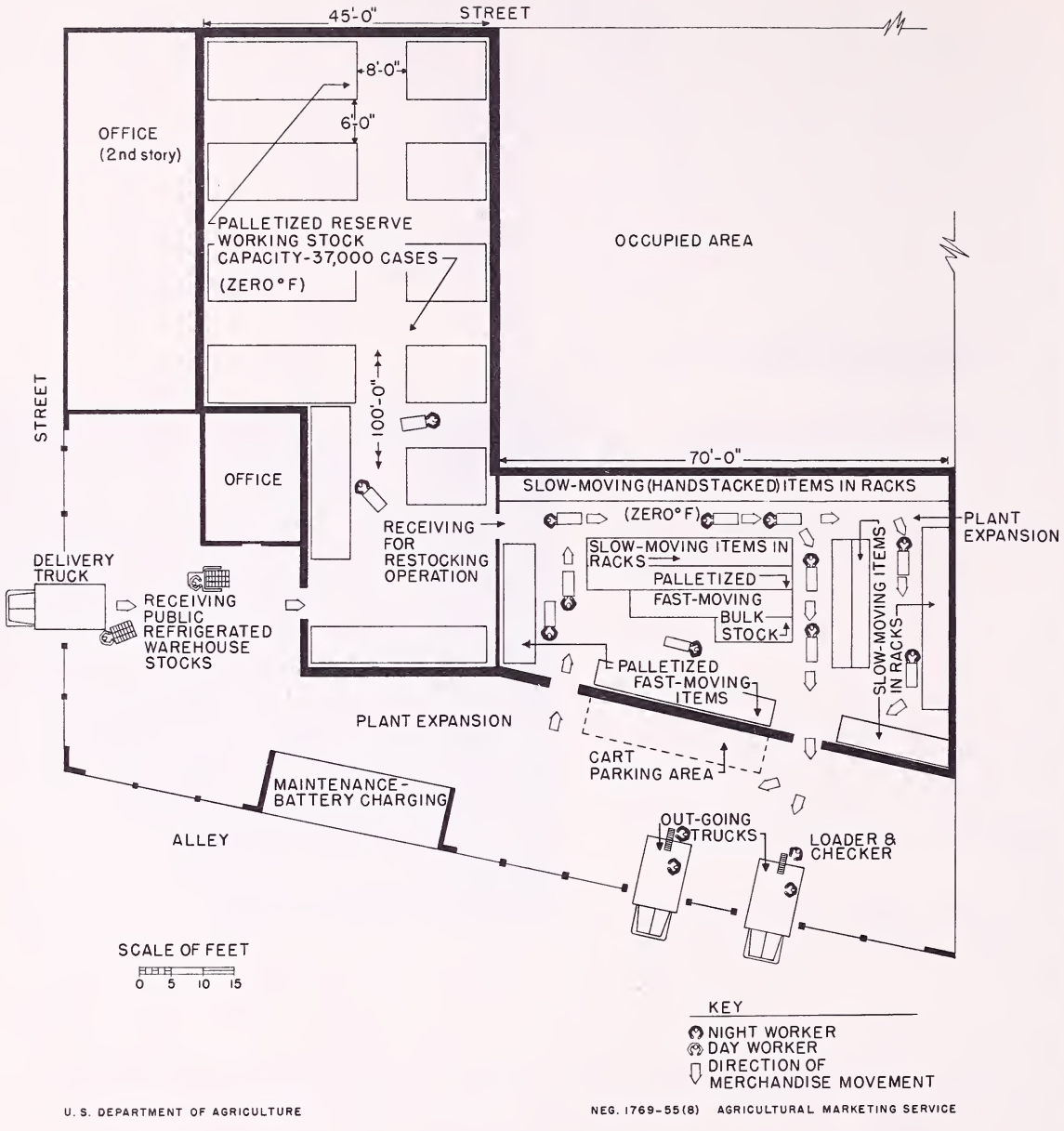

Figure 16.--Plant layout for the single-deck cart operation showing travel path of order fillers.

Figure 17.--Racks with adjustable shelves are used for hand stacking slow-moving frozen food items.

wheel conveyor section is used for moving the merchandise across the tailgate and into the trucks. The floors of the cold storage rooms are at street level. A loading platform of truckbed height is not available.

Labor Requirements and Productivity

Analyses of the two systems studied show considerable increases in productivity for the various operations under the new system. The man-hours required in receiving were reduced 64 percent. This was accomplished by palletizing and increasing the flexibility of operations in the expanded plant structure. Order assembly required about 30 percent fewer man-hours, owing to the use of carts instead of wheel conveyors. However, the labor required for truckloading in the new operation was increased 100 percent, mainly because of the need for 2 men in each of the 2 loading crews instead of 1 man in each crew as required in the former operation. This could be reduced if loading platforms were available and large enough doors were installed in the trucks to permit the carts to be moved directly into the trucks to the points where the merchandise is stowed. In this case only 1 man would be required instead of 2. Table 5 compares the distribution of time in the order assembly operations of the new system. As shown in table 5, *order filling* time amounts to 43 percent of total man-hours, which is considerably more than the 23 percent in the wheel conveyor system. Delay time, which amounts to about 17 percent in the former operation, has been reduced to about 6 percent in the cart system. About 12 percent of the working time in the cart system is spent in *pushing carts*. This corresponds to 10 percent of time required in the wheel conveyor system to push cartons along the conveyor.

The total daily requirements for handling 900 orders of frozen foods were reduced from 200 man-hours to 144 man-hours or from approximately 0.22 man-hour per order to 0.16 man-hour per order.

Table 5.--Percentage distribution by specified operations of the labor time of a 16-man crew employed in a selected wholesale frozen food plant for filling orders and loading delivery trucks by use of single-deck carts

Operation	Distribution of work time as a percent of total time	
	Productive	Unproductive
	Percent	Percent
1. Filling orders	43	
2. Examining, marking, and handling invoices	8	
3. Waiting for work (delay time)		6
4. Pushing carts		12
5. Unproductive walking		0
6. Checking orders and marking cartons	9	
7. Loading delivery trucks	13	
8. All other 1/	9	
Total	82	18

1/ Includes about 15 small work elements.

Comparison of the Old and New Handling Systems

The comparative annual costs of receiving, order assembly, and truckloading operations by the old and new handling systems are shown in table 6. The total annual saving on the 4 items of cost is approximately $16,300. The average cost per order by the old handling system was $0.397. By the new system the cost of handling an order was reduced to $0.324, a saving of $0.073 per order.

With annual savings of approximately $16,300 it was possible to pay for the new equipment, which cost $9,355, in less than 1 year.

Table 6.--Comparative annual costs of 2 methods of handling and storing frozen foods in a wholesale distribution plant filling an average of 900 orders aggregating over 2,000 cases daily 1/

Methods and equipment	Crew size	Labor	Equipment	Storage charges	Rent	Total
	Number	Dollars	Dollars	Dollars	Dollars	Dollars
Old method:						
During the day 2 workers receive merchandise and 4 workers stock chutes using platform hand trucks and wheel conveyors. During the night 12 workers fill orders, 2 workers check orders, 3 workers replenish the chutes, and 2 workers stow orders in delivery trucks.	25	2/ 75,000.00	3/ 480.00	4/ 5,385.00	5/ 8,400.00	89,265.00
New method:						
During the day 2 workers receive merchandise and stock racks using forklift truck and pallets. During the night 10 workers fill orders using single-deck carts, 2 workers check orders, 2 workers replenish racks, and 2 workers stow orders in delivery trucks.	18	6/ 54,000.00	7/ 2,250.00	8/ 1,885.00	9/ 14,800.00	72,935.00
Savings	7	21,000.00	-1,770.00	3,500.00	-6,400.00	16,330.00

1/ Based on 250 days of operation a year.
2/ 50,000 man-hours (200 man-hours per day for 250 days) at an average rate of $1.50 per hour.
3/ 30 10-foot sections of gravity roller conveyor, 60,000 machine hours at $0.008 per hour $480.00.
4/ Figure obtained through accounting analysis.
5/ 42,000 cubic feet of space at an annual rental of $0.20 per cubic foot.
6/ 36,000 man-hours (144 man-hours per day for 250 days) at an average rate of $1.50 per hour.
7/ Forklift truck 2,000 machine-hours at $0.409 per hour $818.00; 180 feet of pallet racks and bins 2,000 hours of use at $0.2925 per hour $585.00; 400 (36- by 48-inch) pallets 400 hours of use in actual handling operations (excluding storage) at $1.3953 per hour $558.12; 35 carts 2,000 hours of use at $0.1444 per hour $288.80.
8/ Annual estimate based on 1 month's operations.
9/ 74,000 cubic feet of space at an annual rental of $0.20 per cubic foot.

CASE STUDY NO. 3--SUBSTITUTION OF MULTIPLE-DECK CARTS, FORKLIFT TRUCK, AND PALLETS FOR GRAVITY-TYPE ROLLER CONVEYORS, CHUTES, AND 4-WHEEL HAND TRUCKS

Both the power roller conveyor and the single-deck cart systems work effectively for order assembly operations when delivery trucks are available at the plant while the orders are being filled. However, these systems lose some of their effectiveness when it is necessary to assemble orders while trucks are away from the plant making deliveries. Orders assembled during the day when delivery trucks are on their routes are held in the freezer room until the trucks have returned. For this reason it is desirable to have a cart of greater capacity than the single-deck cart, so that several orders can be held without unloading until the delivery trucks are ready. Large-capacity, multiple-deck carts appeared to be suitable for this type of operation. They offered considerable flexibility for use in both small- and large-volume frozen food distribution plants.

This distributor handles an average daily volume of about 1,000 cases of frozen foods, stocks about 260 items, and on peak days loads out about 200 orders. The orders average about 9 items each, most of which are called for in less than case lots. The distributor uses an invoice which lists about 80 of the 260 items with blank lines for writing in the items not listed. This type of preprinted invoice appeared to slow down the order fillers as compared with the invoices in other plants which list only the required items. The items were placed on invoice sheets by punchcard tabulating machines.

Equipment, Facilities, and Work Methods Before Improvements Were Made

Gravity-Type Roller Conveyor Order Assembly Line

Prior to the study, this plant used 2 roller conveyor lines, each approximately 50 feet long, and separated by piles of working stock in connection with order assembly operations. Packing tables were not used; packing and case splitting were performed on the conveyors.

Layout of the Plant

Before installation of the multiple-deck cart system, the plant consisted of a zero room measuring about 60 feet wide and 70 feet deep, with a ceiling height of approximately 10 feet (fig. 18). Since the room was not equipped with racks, merchandise was arranged in bulk stacks. Adjoining this room was a small unrefrigerated space 15 feet square, which was used as a work area for checking orders and as a receiving and loading-out apron. A platform 39 inches high and 12 feet wide adjoined this area.

The freezer room contained a total of 44,300 cubic feet of space which at an assumed rental rate of 20 cents per cubic foot had an annual rental value of $8,860. The maximum capacity of the zero room, allowing for aisles and clearances, was about 22,000 cases of frozen foods or about 3 weeks' inventory.

Methods of Operation

In the old system 2 workers were employed during the day for receiving merchandise, rehandling it in the freezer room when necessary to make room for incoming products, cleaning up and adjusting the stock, and filling a few rush orders. The merchandise was moved into the freezer room from the receiving apron by 4-wheel hand trucks. In the freezer room it was necessary to hand stack the cases in previously established stacks or in cleared areas. Because specific space assignments were not allotted each item, and also because of the absence of racks, frequent rehandling of the merchandise was necessary in order to make room for incoming products.

Orders were assembled at night by a crew of 4 order fillers and 1 checker. Invoices were arranged according to routes and in delivery sequence before being sent to the order assembly room. Two men, working independently, filled an order by using the gravity conveyor, and loaded the order on a 4-wheel hand truck. After 3 or 4 orders were loaded on a truck, it was pushed to the adjacent warm room checking area. In checking orders, packages were removed from the hand truck on which they initially had been loaded and stacked on another 4-wheel hand truck. When as many orders as possible had been stacked on this second hand truck it was pushed into the freezer room and left until the next morning when delivery trucks were loaded out. It frequently was necessary to place these loaded hand trucks in the aisles, thus hampering somewhat the work pattern of the order fillers.

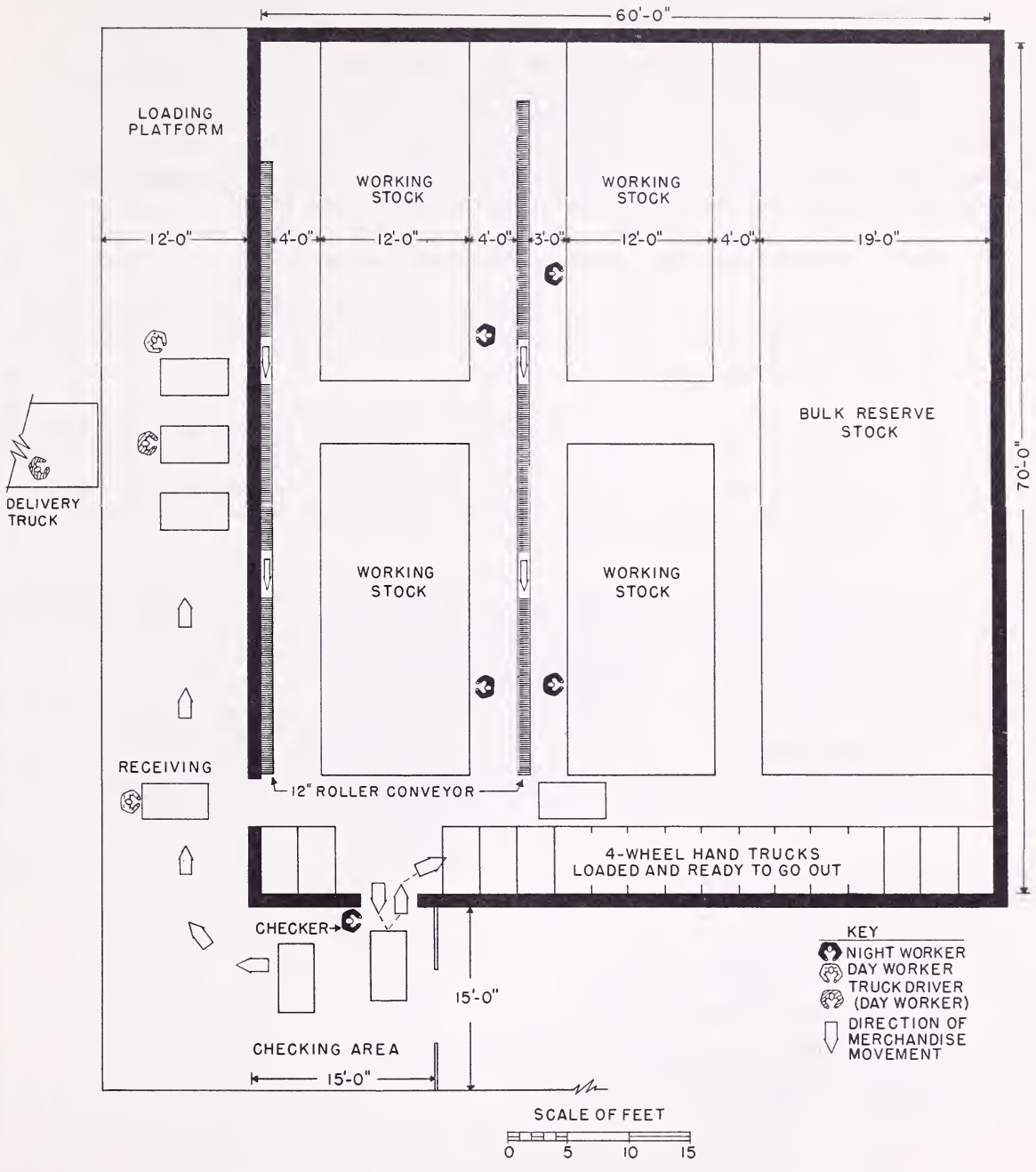

Figure 18.--Plant layout of operation before converting to a palletized receiving and multiple-deck cart system.

Delivery trucks were loaded out early in the morning by a member of the day crew and the truck drivers. This operation was performed by pushing the loaded hand trucks out to the delivery trucks, setting up a wheel conveyor section from the platform into the truck, and conveying the merchandise across the truck tailgate. (The truck doors were too small to permit the entrance of the hand truck; therefore, the hand trucks were off-loaded and the wheel conveyor section was used.) A loading crew consisted of 3 workers: 1 called out the orders and checked the number of pieces in each order, 1 off-loaded the hand trucks and pushed the packages along the conveyor into the delivery truck, and another removed the merchandise from the conveyor and stacked it in the delivery truck.

Labor Requirements and Productivity

The total daily labor requirements for handling 200 frozen food orders into, within, and out of the plant were 61-1/3 man-hours, 4/ or an average of 0.31 man-hour per order. This includes both productive and unproductive labor.

The results of a work sampling study of order filling and truckloading operations made in this plant are shown in table 7. The total unproductive time of 33 percent is accounted for by delays on the part of order fillers waiting for work, pushing cartons on the conveyor line from one work station to the next work station, unproductive walking, and handling the orders, after assembling, for checking purposes.

Table 7.--Percentage distribution by specified operations of the labor time of a 7-2/3 man crew 1/ employed in a selected wholesale frozen food plant for filling orders and loading delivery trucks by use of gravity-roller conveyor and 4-wheel hand truck

Operation	Distribution of work time as a percent of total time	
	Productive	Unproductive
	Percent	Percent
1. Filling orders	22	
2. Examining, marking, and handling invoices	14	
3. Waiting for work (delay time)		15
4. Pushing cartons on conveyor		7
5. Handling orders after assembling 2/		8
6. Unproductive walking		3
7. Checking orders and marking cartons	9	
8. Loading delivery trucks	12	
9. All other 3/	10	
Total	67	33

1/ Part of one truck driver's time included in the crew.
2/ From conveyor to hand truck; to hand truck for checking purposes; to delivery truck.
3/ Includes about 12 small work elements.

4/ Part of one truck driver's time (2/3 man-day per day) is included in this total.

The new system, which is described in the following section of this report, provided a means for reducing unproductive time and for increasing operational efficiency.

Equipment, Facilities, and Work Methods After Improvements Were Made

Multiple-Deck Cart System

The multiple-deck cart is 33 inches wide, 50 inches long, and 72 inches high, and has the following features: (1) Roller bearing wheels, lubricated to operate with maximum effectiveness at zero degrees; (2) resinoid plastic wheel rims that will not stick to freezer floors; (3) swivel-type rear wheels, with front wheels mounted in a fixed position; (4) a writing shelf for holding invoices; (5) a metal divider screen running vertically, lengthwise through the center of the cart; (6) 3 shelves, including a bottom deck, on each side of the dividing screen, or a total of 6 shelves on each cart; (7) 2 shelves on each side of the cart are hinged so that they can be tilted against the screen to facilitate loading and unloading; (8) all of the shelves are slanted toward the center of the cart to aid in stacking the cartons; and (9) a shelf for the invoice sheets is located at the push bar end of the cart (figs. 19 and 20).

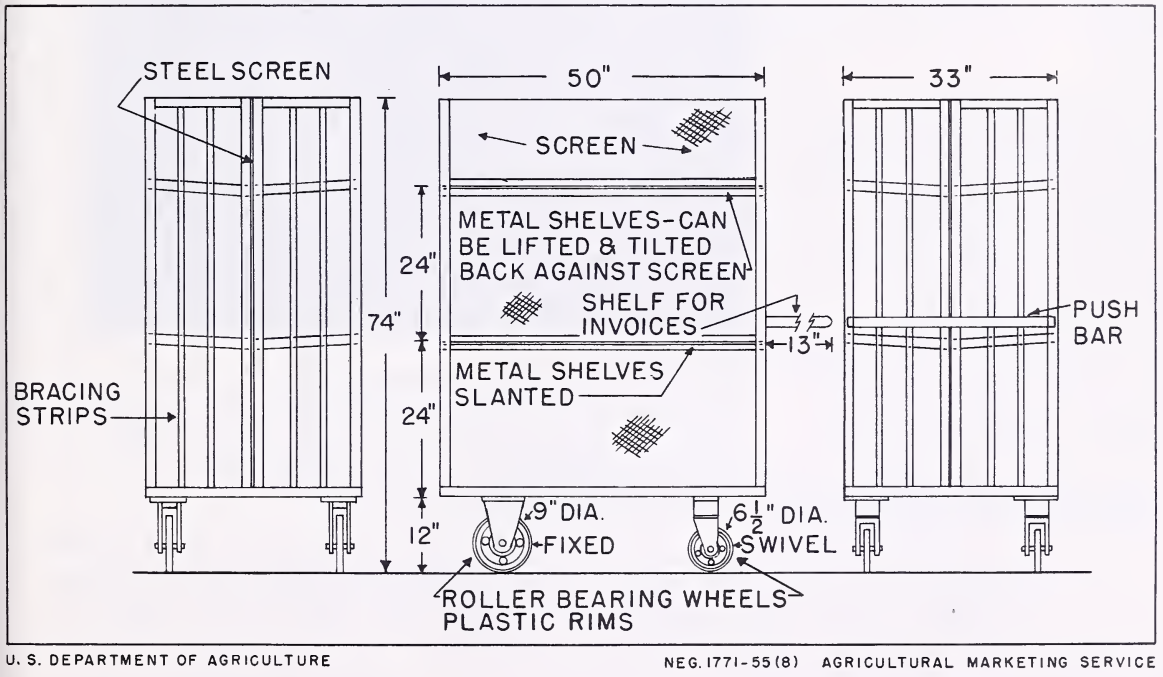

Figure 19.--Major dimensions of the multiple-deck cart used for order selection.

As these carts are not as maneuverable as the single-deck cart previously described, they are usually parked near the center of the order selection area and moved only to enable the worker to pick up several cases of an item. Each order filler assembles a complete order and loads it on the proper cart. The last 2 digits of the invoice number are put on the outside end of each carton and may also be placed on a blackboard attached to one end of the cart. Each cart will hold from 5 to 15 orders, depending on the size of orders. When a cart

has been loaded it is pushed to the cart-parking area near the exit door and an empty cart is pushed into position in the center of the working area by the worker on his return trip. Orders are usually selected in radial fashion from the center of the room rather than in circular fashion as with the single-deck cart.

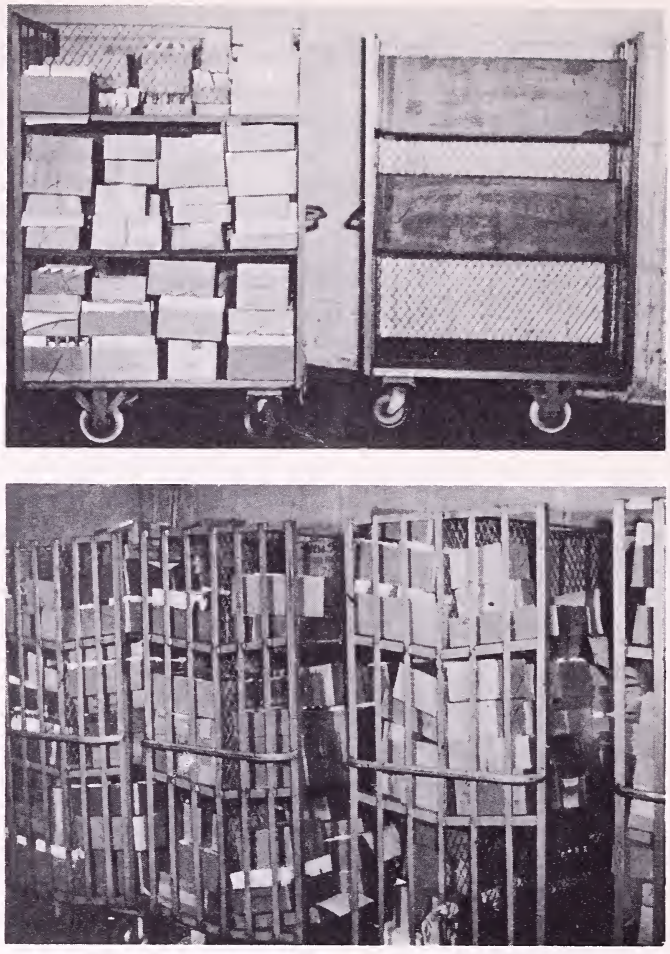

Figure 20.--Multiple-deck carts used for order selection. Top: Side view of a loaded cart, and an empty cart with shelves raised. Bottom: End view of loaded carts in the parking area.

Layout of the Plant

As shown in figure 21 the dimensions of the order assembly (breakup) room have not been changed. However, the arrangement of the stock within the room has been reorganized to permit the palletization of unit loads of frozen foods.

The multiple-deck cart system was installed in the same room used in former operations but equipped with racks and bins (fig. 21). A few of the faster-moving items are placed in temporary bulk storage near the entrance to the order assembly room and a small part of the room was set aside for bulk storage of reserve stock. Additional reserve stocks are kept on top of the racks. About 75 percent of the total volume handled is palletized. The remaining 25 percent of the volume consists of slow-moving items which are hand stacked. Since the central part of the room is the center of activity in order selection, the faster moving items are stacked near the center towards the entrance. The lower-volume items are located farthest from the center. Items are stacked according to commodity type.

Aisles are arranged so that the order fillers can easily move from one location to another. All of the aisles are 6 feet 6 inches wide. This width is adequate to allow 2 carts to pass and is of sufficient width for the straddle-type forklift fork truck used in re-stocking. An area is provided near the exit door for parking loaded carts. Empty carts are parked outside the order assembly room on the loading dock. Although there were no changes in the size of the plant, the storage capacity of the new facilities was slightly increased. However, it is assumed to be the same as in the old system, 22,000 cases, or about 3 weeks' inventory.

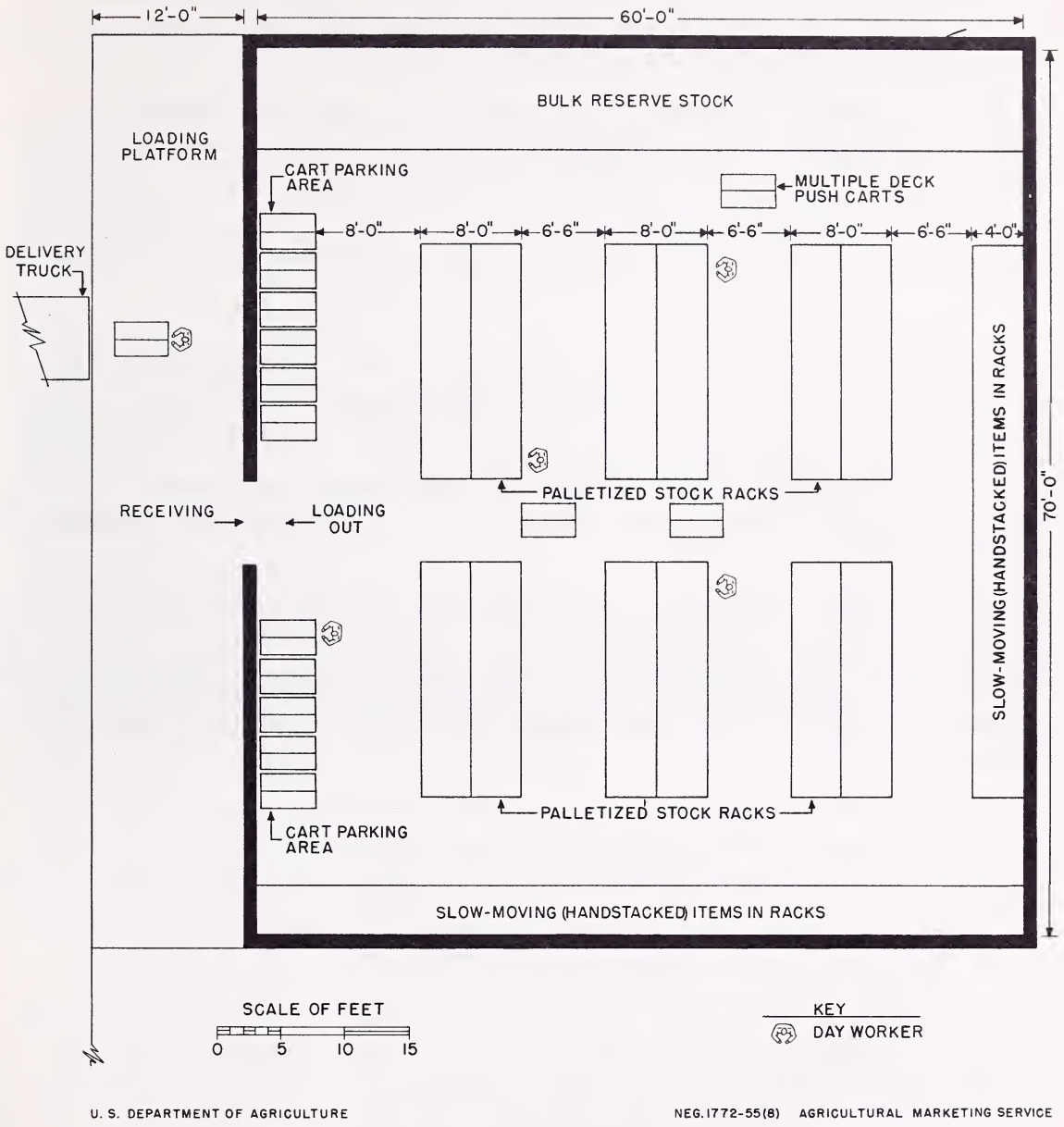

Figure 21.--Layout of multiple-deck cart operation. Orders are assembled using centrally located carts as the hub of operations; night work has been eliminated.

Methods of Operation

Receiving, order assembly, and truckloading operations are performed during the day and the early part of the evening. Except for early evening, night work has been eliminated, and only 5 workers are employed for all operations.

One worker who doubles as an order filler receives all frozen foods. Incoming merchandise is picked up on the receiving apron, or at the tailgates of trucks, in pallet loads, transported into storage, and stacked in its allocated space in bulk or on top of racks in the assembly room. Only 10 to 15 percent of the merchandise is rehandled once it has been placed in its assigned location, and then only to make room for a new pallet load. The routine of restocking from the reserve supply located in the room in bulk or on top of the racks is the same as it is for restocking from the receiving apron.

Orders are taken by salesmen during the day, assembled by order fillers and loaded into delivery trucks the same day, then delivered the next day. Orders are phoned in by salesmen beginning about 10 a.m.; recorded on dictating equipment, transcribed by a clerk to an invoice sheet, and sent immediately to the order assembly room without aligning them by route sequence. Four order fillers come to work at staggered hours, but all of them are working during the latter part of the afternoon when order receipts are heaviest. All orders received by 4 p.m. are delivered that day. Orders called in by salesmen after this time are delivered the next day.

Each delivery route is designated by a predetermined route number and orders are called in by salesmen in nearly the same sequence in which they are to be delivered. The orders are filled as they are received, although their delivery sequence cannot be completely determined until all of the orders have been received. This does not constitute a problem, however, because the multiple-deck carts are designed with several shelves to overcome this disadvantage.

Delivery trucks are loaded one at a time by a crew of 3 workers who push the loaded carts onto the platform and load out the truck by a gravity conveyor. Invoices are routed according to delivery sequence, so that orders will be loaded in the proper sequence in which they are to be delivered. As the order moves along the conveyor, it is checked as to the number of packages and number of master cartons (pieces). The stacking of orders individually on the cart shelves and the numbering of the orders, both on the cartons and on a blackboard attached to the end of the cart, enable the orders to be selected rapidly. The volume of business in the plant studied necessitated the use of 15 carts. In addition, the company purchased 1 straddle-type fork truck, 500 36- by 48-inch pallets, 8 racks placed back to back, and 2 wall racks. The fork truck is used about one-third of the time on a subsidiary operation not related to frozen food handling.

Labor Requirements and Productivity

The results of a work sampling study of order filling and truckloading operations after improvements were made are shown in table 8. The use of multiple-deck carts increased the productive time spent in filling orders from 22 percent in the former system to 41 percent in the improved system. Waiting for work was reduced from 15 to 3 percent, pushing cartons on conveyors which accounted for 7 percent of the total working time was replaced by the time spent in pushing carts amounting to 3 percent. Handling orders for checking

Table 8.--Percentage distribution by specified operations of the labor time of a 5-man crew employed in a selected wholesale frozen food plant for filling orders and loading delivery trucks by use of multiple-deck carts and straddle-type forklift truck

Operation	Distribution of work time as a percent of total time	
	Productive	Unproductive
	Percent	Percent
1. Filling orders	41	
2. Examining, marking, and handling invoices	13	
3. Waiting for work (delay time)		3
4. Pushing cartons on conveyor		3
5. Unproductive walking		1
6. Checking orders and marking cartons	11	
7. Loading delivery trucks	17	
8. All other 1/	11	
Total	93	7

1/ Includes about 10 small work elements, in addition to receiving and stocking operations.

purposes, which accounted for 8 percent of the total working time, was entirely eliminated. Checking orders and marking cartons, which formerly accounted for 9 percent of the total work time, was increased to 11 percent. In addition, the time for loading delivery trucks was increased from 12 to 17 percent because orders are checked while being loaded into delivery trucks.

The total daily labor requirement for handling approximately 1,000 cases of frozen foods was reduced from 61-1/3 man-hours to 40 man-hours, or from approximately 0.31 man-hour per order to 0.20 man-hour per order.

Comparison of the Old and New Handling Systems

The comparative annual costs of receiving, order assembly, and truckloading operations by the old and new handling systems are shown in table 9. The total annual saving of labor and equipment costs shown is approximately $6,570. The average cost of labor and equipment per order by the old handling system was $0.47. By the new system this was reduced to $0.34, a saving of $0.13 per order on labor and equipment.

With annual savings of approximately $6,570 it would be possible to pay for new equipment costing $9,435 in less than 2 years.

Table 9.--Comparative annual costs of 2 methods of handling and storing frozen foods in a wholesale distribution plant filling an average of 200 orders, aggregating 1,000 cases daily 1/

Method and equipment	Crew size: Number	Labor: Dollars	Equipment: Dollars	Total 2/: Dollars
Old method:				
During the day 2 workers receive merchandise and stock freezer room using 4-wheel hand trucks. During the night 4 workers fill orders and 1 worker checks orders. Delivery trucks are loaded in the morning by day crew and truckdrivers taking loaded hand trucks from freezer room where they were parked by the night crew.	3/ 7-2/3	4/ 23,000.00	5/ 428.00	23,428.00
New method:				
During the day (nightwork eliminated) 1 worker receives merchandise by straddle-type forklift truck and stacks it in order assembly room. Four order fillers use multiple-deck carts. Delivery trucks are loaded by truckdrivers, as noted above.	5	6/ 15,000.00	7/ 1,862.40	16,862.40
Savings	2-2/3	8,000.00	-1,434.40	6,565.60

1/ Based on 250 days of operation a year.

2/ Since there was no change in the physical structure of the distribution plant there was no change in rental cost, thus this cost is not included in the total. In addition, while there was a small increase in storage capacity in the improved plant layout it has not been included herein.

3/ Part of the truckdriver's time (2/3 man-day per day) is included in this total.

4/ 15,333 man-hours (61 1/3 man-hours per day for 250 days) at an average rate of $1.50 per hour.

5/ Twenty 4-wheel hand trucks 40,000 machine-hours at $0.0063 per hour $252; 11 10-foot sections of gravity roller conveyor 22,000 machine-hours at $0.008 per hour $176.

6/ 10,000 man-hours (40 man-hours per day for 250 days) at an average rate of $1.50 per hour.

7/ Forklift truck 1,334 machine-hours at $0.409 per hour $545; 500 36-by 48-inch pallets 500 hours of use in actual handling operations (excluding storage) at $1.3953 per hour $697.65; 100 feet of pallet racks 2,000 hours of use at $0.124 per hour $248; 15 multiple-deck carts 2,000 hours of use at $0.1856 per hour $371.75.

CONCLUSIONS

As the size and layout of a distributor's plant, his volume of business, the amount of the services rendered, and capital investment required, vary by individual plants, the cost previously shown for the three handling systems studied also would vary. However, under comparable conditions, the handling systems described should result in improved handling efficiency and reduced operating costs.

For the plants in which these studies were made, the order of effectiveness of methods covered is as follows:

1. Single-deck cart system
2. Multiple-deck cart system
3. Power roller conveyor system

Advantages and Disadvantages of the Cart Systems

Advantages

1. When used with industrial forklift trucks and pallets, the single-deck cart system increased productivity 39 percent and the multiple-deck cart system increased productivity 53.4 percent over the 4-wheel hand truck and roller conveyor systems formerly used by the respective plants studied.

2. The multiple-deck cart system permits orders to be filled while delivery trucks are out of the plant.

3. With the cart systems more than one delivery truck can be loaded at one time.

4. A distributor, using either of the two cart systems described in this report, particularly the multiple-deck cart, can use the same crew both for loading-out delivery trucks and for assembling orders.

5. The jobs (invoices used in order assembly) assigned to each order filler in the cart system are, for the most part, independent of the jobs assigned to other order fillers. This reduces the number of delays in filling orders.

6. Since the cart operators work independently, constant supervision is not as necessary as in the power conveyor system. Also the slowest worker does not set the pace for the entire operation.

7. Cart systems afford opportunities for maintaining effective production controls, incentive systems, and the like on an individual as well as a group basis.

8. Although the initial investment required for carts is almost as large as for the power conveyor system, the combined cost of ownership and operation is less.

9. The only limitations on the volume of frozen food that can be handled by the use of carts are limitations imposed by the floor areas and walking distances to be traversed by the order fillers.

Disadvantages

1. When single-deck carts are used, it is preferable to load the delivery trucks available during the order filling operations. Although this is not essential, concurrent truckloading is recommended in order to keep the cart inventory as low as possible and to avoid the necessity of storing the carts in the freezer room.

2. The cart systems require additional handling of the cartons.

3. No method has been developed to provide automatic marking or counting devices with the cart systems.

4. Case splitting requires additional space for effective repacking and the carts do not provide sufficient shelf space.

5. Order fillers need to familiarize themselves with the entire working stock, whereas in the power conveyor system the worker needs only to familiarize himself with the stock at his work station.

Advantages and Disadvantages of the Power Roller Conveyor System

Advantages

1. The power roller conveyor system, in which a forklift truck and pallets were used, increased the productivity of the order assembly operation 37.5 percent over the former roller conveyor and 4-wheel hand truck system.

2. In the power conveyor system, cartons are conveyed through the order assembly room and into the truck with only two handlings by the order fillers: One in putting merchandise onto the conveyor, the second in taking it off the conveyor and stowing it in the delivery truck.

3. The power conveyor permits opportunities for automatically marking cartons with stop numbers and for installing automatic counting devices which may be used in error and inventory control.

4. The wheel conveyor attached to the sides of the power conveyor table provides suitable work space for splitting and repacking cases. Although working shelves are provided on both types of cart, they are small and not conducive to efficient case splitting or repacking.

5. The table above the conveyor lines, as well as the hinged conveyor section noted above, provides space for keeping cartons and partly filled cases.

6. Each order filler in the power conveyor system needs to become familiar with the location of only a part of the total working stock.

Disadvantages

1. In the power roller conveyor system, delivery trucks must be loaded during order assembly operations and only one truck at a time may be loaded. Additional work is needed to determine the feasibility of loading more than one truck at a time by this method.

2. The power conveyor system requires a man in the truck to load the cartons as they come off the conveyor. This worker, who is idle part of the time, cannot be used for order assembly.

3. In the power conveyor system the order assembly line may occasionally be paced by the slowest operator.

4. Constant supervision is required to relieve or eliminate bottleneck situations as they occur.

5. The power conveyor system's optimum effectiveness is limited to distributors whose volume requires about 4 workers for order filling. This volume does not keep the truckloader busy 100 percent of the work time. In smaller operations he is likely to work less than 50 percent of the time.

6. Separate power conveyor systems must be added when a plant's volume exceeds the capacity of one power conveyor, since there is a definite limitation (from the standpoint of efficient operation) to the number of men that can be placed at work stations on the power conveyor. Therefore, space for expansion must be considered as a limiting factor in the use of a power conveyor system. In the cart systems, additional men and carts may be added before space for expansion is required.

7. The power conveyor system can be used profitably only in a room large enough to contain: The conveyor, piling space for palletized frozen food products, and aisles wide enough (when the sides of the power roller conveyor are folded down) to operate a small forklift truck. Space requirements are not as limiting a condition for the cart systems, since the smallest profitable cart system depends entirely on the smallest volume of frozen food products that can be handled profitably.

APPENDIX

Cost of Ownership and Operation of Various Types of Materials-Handling Equipment

The costs incurred when materials-handling equipment is used in frozen food handling can be grouped into two major categories: (1) Ownership costs, which are considered to be fixed or relatively stable from year to year over a wide range of equipment use; and (2) operational costs, which are variable and fluctuate in direct relationship with the hours of use of the equipment.

Equipment ownership costs include depreciation, taxes, interest, and insurance. When equipment is purchased, the owners are entitled to recover the purchase price of the equipment and accessories by the time it reaches the end of its economic life. This useful life, in years, varies for different types of materials-handling equipment and the use to which it is put. For purposes of straight line depreciation, the method used in this study to obtain the annual rate of depreciation was to divide the total cost of equipment by the number of years of its estimated life. State and municipal taxes, interest on the capital invested, and insurance premiums covering fire, disaster, and other forms of protection applicable to the materials-handling equipment, are the other items that round out the ownership costs, and are paid on an annual basis regardless of hours of use.

Costs of operation computed in this study for mechanical and electrical equipment include oil, electricity, maintenance, repairs, overhauling, inspection, servicing, and depreciation. Even when equipment is not used for extended periods, some wasting of the equipment is incurred in the form of deterioration of such parts as tires and batteries, and this factor is recognized in the depreciation rate.

Total hourly costs of ownership and operation of specified types of materials-handling equipment are shown in table 10. These hourly cost rates are based on assumed hours of annual use and other factors. Plants in which the actual annual hours of use of a specified type of equipment exceed the assumed hours of use probably would incur lower average hourly costs than those shown in table 10. Conversely, plants in which annual usage of a machine falls below the assumed hours of use probably would incur higher average hourly costs.

Equipment inputs for all methods discussed in the report are in terms of *machine-hours* for each type of equipment employed. Equipment costs can therefore be recomputed by any plant operator at any future time by substituting his own equipment costs for those used in this report.

Research Methods and Techniques

Work Sampling Method

The method of obtaining the data shown in the tables of this report is based on what is commonly called work sampling, or ratio delay studies in industrial engineering parlance. This method is a way of obtaining information concerning the performance of workers and equipment. It replaces 100 percent observations, or time study, with a random sampling procedure, and in this study was used in order to obtain percentages of working or idle time for order assembly operations in frozen food distribution plants.

Table 10.—Cost of ownership and operation of various types of materials-handling equipment used in frozen food distribution plants

Type of equipment	Amount of equipment	Initial cost 1/	Years' depreciations 2/	Assumed use per year	Depreciation	Interest at 5 percent	Insurance and taxes at 4 percent	Total	Operation cost per year: Electricity 3/	Operation cost per year: Maintenance 4/	Operation cost per year: Total	Total ownership and operating cost: Per year	Total ownership and operating cost: Per hour of use
	Units	Dollars	Number	Hours	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Riding-type straddle forklift truck (3,000-ton capacity, electric) machine	1	3,425.00	10.0		342.50								
Battery 5,046 kilowatt-hour capacity	1	435.90	6.3		72.05								
Charger	1	404.00	10.0		40.40								
Total	-	4,282.90		2,000	454.95	107.07	171.32	733.34	5/ 20.20	64.24	84.44	817.78	0.409
Power conveyor	1	5,600.00	10.0	2,000	560.00	140.00	224.00	924.00	6/ 15.00	84.00	99.00	1,023.00	.512
4-wheel hand truck (capacity 2,500 - 3,500-pound, steel wheels, platform size 30- by 66-inch)	1	47.92	10.0	2,000	4.79	1.20	1.42	7.91		4.79	4.79	12.70	.0063
Gravity roller conveyor (12-inch wide by 10 feet long with 2 adjustable supports)	1	60.67	10.0	2,000	6.07	1.52	2.43	10.02		6.07	6.07	16.09	.0080
Storage bins	100 feet	1,500.00	10.0	2,000	150.00	37.50	60.00	97.50		150.00	150.00	247.50	.124
Storage racks and bins	120 feet	2,000.00	15.0	2,000	133.33	50.00	80.00	130.00		200.00	200.00	330.00	.165
Storage racks	180 feet	2,200.00	10.0	2,000	220.00	55.00	88.00	363.00		220.00	220.00	583.00	.2925
Single-deck cart	35	1,750.00	15.0	2,000	116.67	43.75	70.00	113.75		175.00	175.00	288.75	.1444
Multiple-deck cart	15	2,250.00	15.0	2,000	150.00	56.25	90.00	146.25		225.00	225.00	371.25	.1856

1/ Obtained from manufacturer of equipment: Riding-type, straddle forklift truck, electric, f.o.b., Philadelphia, Pa.; 4-wheel hand truck, f.o.b., Faribault, Minn.; and pallets, f.o.b., Cleveland, Ohio, New York, N. Y., and Washington, D. C.

2/ Bulletin "F" of the Internal Revenue Service was used as a guide in determining the number of years which are to be allowed for depreciation. For most of the above items it is felt that considerably more time would be allowed; however, in order to be conservative in estimating savings accruing from improvements, the minimal depreciation time was used.

3/ Average cost in industry electricity $0.01 per kilowatt-hour.

4/ Maintenance costs computed as a percentage of initial costs, as follows: Electric trucks and power conveyor - 1-1/2 percent; hand trucks, gravity roller conveyors, racks and bins, carts, and pallets - 10 percent.

5/ Power costs for battery charging of electric-powered vehicles computed from manufacturer's specifications. For example: Battery capacity 5.046 kilowatt-hours. Discharge rate per hour 10 percent of battery capacity. 5.046 kilowatt-hour x 0.10 = 0.5046 kilowatt-hour capacity per hour for battery charging. 0.5046 x 2 (50 percent charging efficiency) equals 1.0092 kilowatt charging requirement for each hour of vehicle use. 1.0092 x $0.01 (electricity cost per killowatt-hour) equals charging cost for each hour of vehicle use, or $0.0101. $0.0101 x 2,000 hours equals $20.20 per year, power cost.

6/ Power costs for electric motors on power conveyor table.

The procedure is statistical in nature; the results of random observations are summarized as a period of time the workers or equipment are working or not working. By observing the given operation at random times, it is possible to arrive at percentages of operation and nonproductive time, and with these facts improvements may be made to eliminate inefficient methods, schedules, and equipment. The number of observations made depends on the degree of accuracy required. There is a point where, to obtain greater precision, the number of observations must be increased beyond economical levels. The work sampling technique is less time consuming for most requirements than ordinary time study.

How Observations Were Made

An observation route sheet enabled the observer to make several studies at a time. The observer arrived at the work station at a preselected time 5/ and made his observation concerning the activity of the employee. At the end of the day's observations the percentages of productive and unproductive times were recorded. After 10 or 15 observations of an element it was determined, approximately, what percentage of the total time was consumed by the element. From this information the total number of observations to be made was determined, and the study was continued until the required number of observations was obtained.

The compilation of a series of ratio delay studies enabled the authors to determine the effectiveness of one handling method compared with another, especially in regard to the amount of idle, or unproductive time that was inherent in the method.

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5/ One of the best ways to select the random time of observation is to use a prepared table of 4- or 5-place random digits comparable to the Rand Corporation, Santa Monica, Calif tables. A number in the table is picked as a starting point, then the numbers are recorded as they occur, progressing either horizontally or vertically, until the desired quantity for the sample has been listed. Any numbers that do not correspond to a coded observation time are discarded. The list of numbers is decoded into the actual times they represent and then they are arranged chronologically.

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